Sciences of Europe

No 185 (2026)

Sciences of Europe
(Praha, Czech Republic)

ISSN 3162-2364
The journal is registered and published in Czech Republic.
Articles in all spheres of sciences are published in the journal.

Journal is published in Czech, English, Polish, Russian, Chinese, German and French, Ukrainian.
Articles are accepted each month.
Frequency: 24 issues per year.
Format - A4
All articles are reviewed
Free access to the electronic version of journal

Edition of journal does not carry responsibility for the materials published in a journal.
Sending the article to the editorial the author confirms it's uniqueness and takes full responsibility for possible consequences for breaking copyright laws.

Chief editor: Petr Bohacek
Managing editor: Michal Hudecek

- Jiří Pospíšil (Organic and Medicinal Chemistry) Zentiva
- Jaroslav Fähnrich (Organic Chemistry) Institute of Organic Chemistry and Biochemistry Academy of Sciences of the Czech Republic
- Rasa Boháček – Ph.D. člen Česká zemědělská univerzita v Praze
- Naumov Jaroslav S., MD, Ph.D., assistant professor of history of medicine and the social sciences and humanities. (Kiev, Ukraine)
- Viktor Pour – Ph.D. člen Univerzita Pardubice
- Petrenko Svyatoslav, PhD in geography, lecturer in social and economic geography. (Kharkov, Ukraine)
- Karel Schwaninger – Ph.D. člen Vysoká škola báňská – Technická univerzita Ostrava
- Václav Pittner -Ph.D. člen Technická univerzita v Liberci
- Dudnik Oleg Arturovich, Doctor of Physical and Mathematical Sciences, Professor, Department of Physical and Mathematical management methods. (Chernivtsi, Ukraine)
- Konovalov Artem Nikolaevich, Doctor of Psychology, Professor, Chair of General Psychology and Pedagogy. (Minsk, Belarus)

«Sciences of Europe» -
Editorial office: Křižíkova 384/101 Karlín, 186 00 Praha

E-mail: info@european-science.org
Web: www.european-science.org

CONTENT

CHEMICAL SCIENCES

Pashayeva A., Kazimova G.
BIOFILM-RESPONSIVE PRODRUG DESIGN: AN EMERGING MEDICINAL CHEMISTRY STRATEGY AGAINST ANTIMICROBIAL RESISTANCE 3

ECONOMIC SCIENCES

Ivanova R.P.
FEATURES OF BULGARIA'S INNOVATION ACTIVITY (2019–2023) 9

PEDAGOGICAL SCIENCES

Mammadzade G., Babayeva N.
METHODOLOGICAL FOUNDATIONS FOR FORMING ECOLOGICAL AWARENESS IN TEACHING THE TOPIC "TYPES OF FUEL AND THE ENVIRONMENT" 16

PHILOLOGICAL SCIENCES

Asgarova Z.
TOPONYMIC COMPONENTS IN BOTANICAL AND ZOOLOGICAL TERMINOLOGY IN THE RUSSIAN LANGUAGE 21

Tursunovna G., Myrzakhanova A.
A COMPARATIVE ANALYSIS OF ACADEMIC WRITING CONVENTIONS IN ENGLISH AND RUSSIAN.....25

PHYSICS AND MATHEMATICS

Starodub Y., Hushchak R.
METHOD FOR DETERMINING THE FLUID TENSION COEFFICIENT USING THE LOGARITHMIC APPROACH 29

Polyanskaya A., Parfentyeva N., Parfentyev N.
TRANSPORT PARTICLES.....31

POLITICAL SCIENCES

Hasanov J.
FROM FUNCTIONAL SPILLOVER TO STRATEGIC VISION: NEOFUNCTIONALIST DYNAMICS IN THE ORGANIZATION OF TURKIC STATES 37

SOCIAL SCIENCES

Cagiran Kendirli H.
EVALUATION OF INNOVATION FROM A STRATEGIC MANAGEMENT PERSPECTIVE AND SMES..... 42

Delgerjargal Maamuu
TIKTOK'S IMPACT ON ONLINE SOCIAL BEHAVIOR IN THE US, UK, PAKISTAN, AND INDONESIA 54

TECHNICAL SCIENCES

Jabbarova K., Jafarov N.
FUZZY IF-THEN RULE BASED DECISION MAKING 67

Jamanbalin K., Jamanbalin B.
SMALL-SIZED DEVICE: "ELECTRONIC LOAD FOR POWER SUPPLIES" 72

Kuletskaia E.
TESTING STRATEGY FOR CONTENT AND DATA MIGRATION IN LARGE DRUPAL PROJECTS 75

CHEMICAL SCIENCES

BIOFILM-RESPONSIVE PRODRUG DESIGN: AN EMERGING MEDICINAL CHEMISTRY STRATEGY AGAINST ANTIMICROBIAL RESISTANCE

Pashayeva A.,
Lecturer, Department of Chemistry Teaching Methodology,
Faculty of Chemistry, Baku State University, Baku, Azerbaijan
Kazimova G.
Student, Faculty of Chemistry, Baku State University, Baku, Azerbaijan
DOI: 10.5281/zenodo.19327206

ABSTRACT

Antimicrobial resistance remains one of the most serious threats to global health, and biofilm-associated infections represent one of its most therapeutically resistant manifestations. Conventional antibiotics are commonly optimized against planktonic bacteria, yet their clinical performance often decreases in mature biofilms because of poor penetration, altered microenvironmental conditions, metabolic heterogeneity, and the presence of tolerant subpopulations. In response to these limitations, medicinal chemistry is increasingly shifting from the design of broadly active antibacterial agents toward the development of context-dependent systems capable of selective activation at the site of infection. One of the most promising directions in this regard is biofilm-responsive prodrug design.

This article reviews the medicinal chemistry rationale behind prodrugs that remain relatively stable during systemic transport but undergo activation in biofilm-specific microenvironments. Particular attention is paid to pH-responsive, enzyme-responsive, redox-responsive, and metabolite-guided activation mechanisms, as well as to the role of linker engineering, physicochemical optimization, and release kinetics in achieving effective antibacterial action. The paper also examines the potential of multifunctional designs that combine antibiotic release with antibiofilm, quorum-sensing-interfering, or antivirulence effects. In addition, key translational barriers are analyzed, including biofilm heterogeneity, insufficient predictive screening models, safety concerns, and regulatory complexity. It is argued that biofilm-responsive prodrugs may redefine anti-infective medicinal chemistry by integrating drug transport, site-selective activation, and microenvironment-aware therapeutic action into a single molecular strategy.

Keywords: Medicinal chemistry, prodrug design, biofilm, antimicrobial resistance, antibacterial agents, quorum sensing, stimuli-responsive therapy.

1. INTRODUCTION

Antimicrobial resistance (AMR) has become a structural challenge for modern medicine rather than a limited microbiological problem. The World Health Organization's 2025 surveillance report drew on more than 23 million bacteriologically confirmed infections reported by over 100 countries, highlighting the scale and persistence of antibiotic resistance worldwide. At the same time, recent global analyses continue to warn that the burden of bacterial AMR will remain severe for decades if drug innovation and stewardship do not improve. Within this crisis, biofilm-associated infections occupy a particularly difficult therapeutic niche. Biofilms are structured microbial communities embedded in an extracellular polymeric matrix that shields microbes from antibiotics, host defenses, and environmental stress. These infections are linked to chronic wounds, implanted medical devices, respiratory disease, and recurrent urinary and gastrointestinal infections. Their persistence is not explained by a single mechanism; instead, it results from matrix-mediated diffusion barriers, altered local chemistry, slow-growing cell populations, and complex microbial communication networks [1, p.17].

This problem has important implications for medicinal chemistry. For decades, most antibacterial drug discovery focused on improving potency against free-living bacterial cells. However, a compound that performs well in standard planktonic assays may show disappointing activity inside mature biofilms. Therefore, future antibacterial design must increasingly consider not only target affinity, but also transport, penetration, local activation, and spatial selectivity within infected tissues.

In this context, prodrug design provides an especially promising framework. Modern prodrug strategies are no longer limited to improving solubility or oral bioavailability; they are also used to achieve selective release, optimize distribution, and reduce off-target exposure. When this logic is transferred to infection microenvironments, the result is a new medicinal chemistry concept: drugs that remain controlled during circulation but become activated preferentially within the chemical and biological environment of a biofilm [2, p.82].

2. Novelty of the Study

The novelty of the present article lies in its focused interpretation of biofilm-responsive prodrug design from a medicinal chemistry perspective. Unlike general reviews on antimicrobial resistance, this paper emphasizes the selective activation of prodrugs within the biofilm microenvironment as a targeted strategy for improving antibacterial efficacy and reducing nonspecific systemic effects. The study also systematizes the main activation mechanisms, including pH-responsive, enzyme-responsive, redox-responsive, and quorum sensing-associated pathways, within a unified conceptual

framework. In addition, the article increases its practical significance by proposing an experimental validation model that links molecular design with stability studies, trigger-dependent activation, antibiofilm assessment, and safety evaluation. Therefore, the paper offers an updated and application-oriented view of biofilm-responsive prodrugs as an emerging and underexplored direction in modern medicinal chemistry.

3. Why Biofilm-Associated Infections Require New Drug Design Principles

Biofilms alter the pharmacological landscape of infection. The extracellular matrix can retard or trap antimicrobial molecules before they reach deeper bacterial layers. Inside the biofilm, cells may enter slow-growing or dormant states in which many classical antibiotics become less effective. Gradients of pH, oxygen, nutrients, metabolites, and redox potential create a heterogeneous microenvironment that differs significantly from standard culture conditions. As a result, medicinal chemistry strategies based only on intrinsic antibacterial potency are often insufficient. This mismatch between traditional antibiotic optimization and the real structure of biofilm infection suggests that antibacterial molecules should be redesigned as dynamic systems rather than static agents. In other words, a useful anti-biofilm molecule must not only bind a bacterial target; it must also reach protected bacterial populations, avoid premature inactivation, and release its active form in a functionally relevant niche [4, p.227,5, p.1359].

Recent literature in drug delivery and microbiome-responsive therapeutics supports this shift. Reviews published in 2025–2026 describe microbial stimuli, enzyme-sensitive systems, environment-responsive carriers, and biofilm-triggered release strategies as rapidly developing approaches. At the same time, recent structure–activity reviews on quorum-sensing inhibitors show continued interest in non-classical antibacterial logic that weakens virulence and biofilm formation rather than relying solely on direct killing. Taken together, these trends make a focused medicinal chemistry discussion of biofilm-responsive prodrugs both timely and original. This is an inference from the current literature landscape rather than a claim that the topic is completely untouched.

4. Concept of Biofilm-Responsive Prodrugs

A prodrug is a chemically modified derivative of a parent drug that undergoes transformation in vivo to release the active agent. In classical medicinal chemistry, prodrugs are widely used to improve absorption, permeability, solubility, metabolic behavior, or tolerability. In the context of biofilm-associated infection, however, the concept gains an additional dimension: selective activation in a disease-specific microenvironment. A biofilm-responsive prodrug can therefore be defined as an inactive or attenuated antibacterial construct that is designed to remain sufficiently stable during systemic transport but to convert into its active form under conditions characteristic of the biofilm niche. These conditions may include acidic pH, elevated esterase or protease activity, altered redox balance, bacterial metabolites, or other microenvironmental triggers. The goal is not simply delayed release, but spatially meaningful release. Such a strategy has several theoretical advantages. First, masking ionizable or reactive groups may improve tissue penetration or matrix transit. Second, restricted activation may reduce systemic toxicity and preserve healthy microbiota more effectively than continuous exposure to the free drug. Third, site-selective activation may produce higher effective concentrations directly within the infected matrix, where conventional dosing often fails.

5. Major Trigger Mechanisms in Biofilm-Responsive Medicinal Chemistry

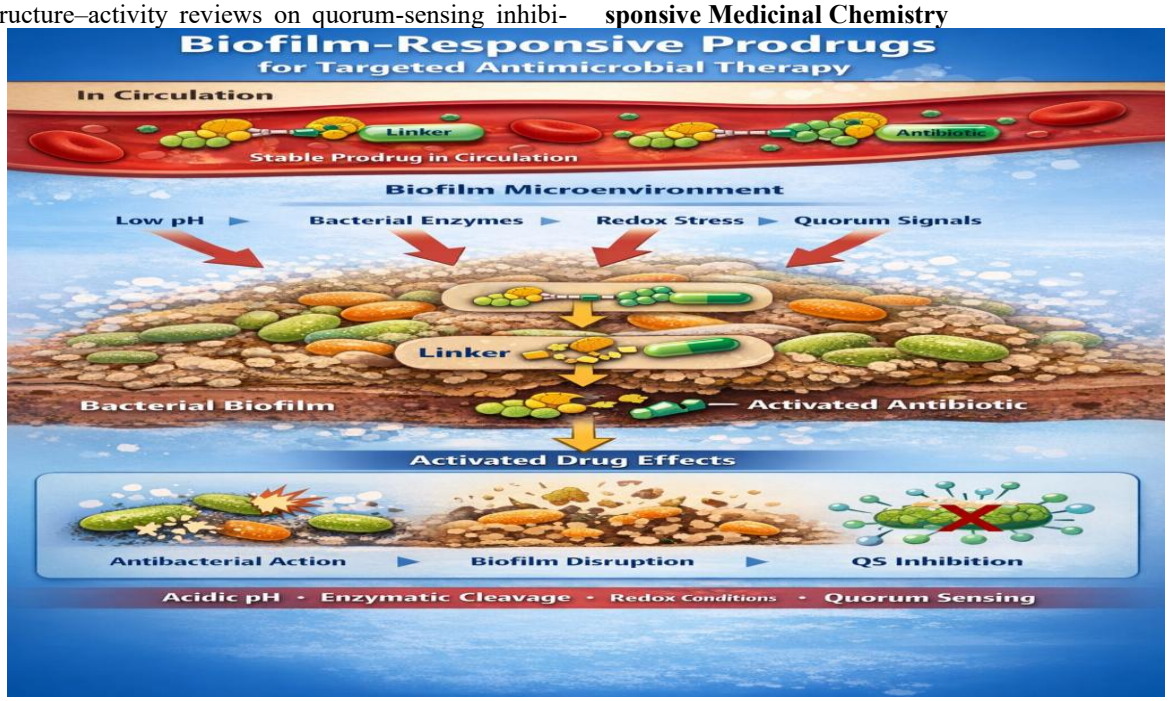


Figure 1. Biofilm-responsive activation of prodrugs in the infection microenvironment.

The prodrug remains stable during systemic circulation and is selectively activated within the biofilm microenvironment by local triggers such as acidic pH, bacterial enzymes, redox changes, and quorum sensing-related signals, leading to the release of the active antibacterial agent.

5.1. pH-Responsive Activation

Many infected and inflamed microenvironments display acidic subdomains generated by bacterial metabolism and host inflammatory processes. In medicinal chemistry, this creates opportunities for acid-labile linkers such as hydrazones, acetals, ketals, and related promoieties. A pH-responsive prodrug can remain comparatively stable at physiological pH while undergoing cleavage in acidic infection zones. The main design challenge is achieving a suitable balance between circulation stability and sufficiently rapid release after target-site accumulation.

5.2. Enzyme-Responsive Activation

Enzyme-responsive systems are particularly attractive because biofilms contain bacterial and host-derived enzymes that may be enriched relative to healthy tissues. Esterases, phosphatases, proteases, glycosidases, and β-lactamase-related activities are among the most relevant triggers discussed in the current literature on microbially activated delivery systems. In medicinal chemistry terms, this allows linkers to be selected not merely for chemical lability, but for biochemical specificity.

5.3. Redox-Responsive Activation

Biofilm interiors often show altered redox status and metabolic stress. Redox-cleavable motifs, including disulfide-linked systems, offer a route to selective activation in such environments. Although redox responsiveness has been explored more extensively in oncology and advanced materials science, newer antibacterial delivery studies suggest that it also has meaningful relevance to infection biology, particularly where inflammation and microbial persistence coexist.

5.4. Biofilm-Associated Metabolite and Signal-Responsive Strategies

A more advanced direction involves responding not simply to generic stimuli, but to microbial products, metabolites, or communication systems associated with biofilm formation. Recent reviews on quorum sensing and quorum-sensing inhibitors emphasize that interference with bacterial signaling can suppress biofilm maturation and virulence without always exerting the same direct selection pressure as classical bactericidal agents. This makes hybrid systems especially interesting: a prodrug might release an antibiotic while simultaneously delivering a quorum-sensing modulator or antibiofilm adjuvant

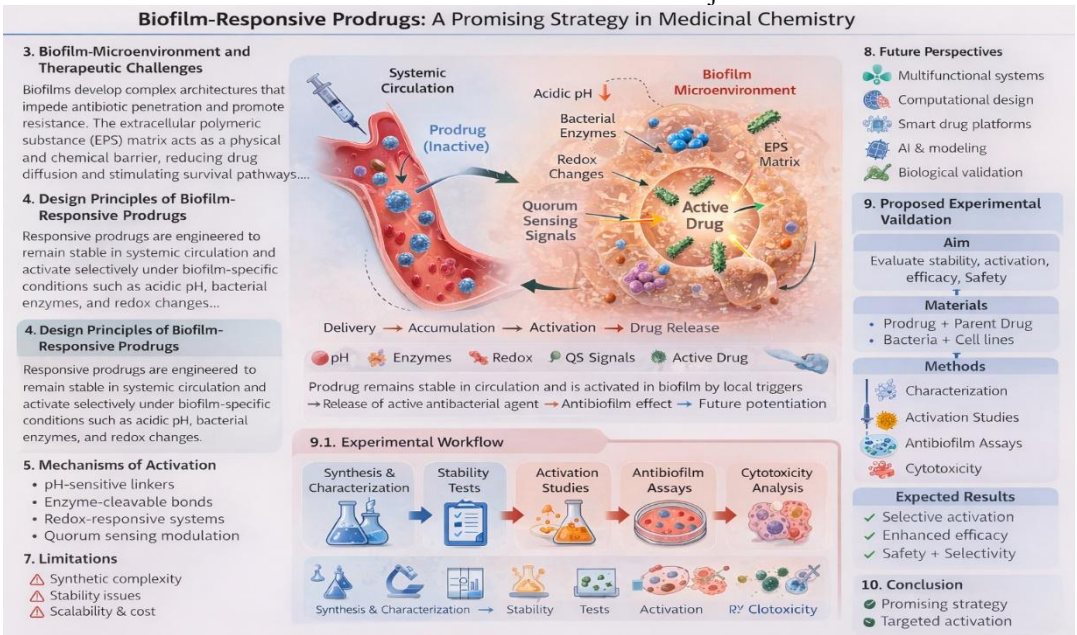

Biofilm-Responsive Prodrugs: A Promising Strategy in Medicinal Chemistry
3. Biofilm-Microenvironment and Therapeutic Challenges
Biofilms develop complex architectures that impede antibiotic penetration and promote resistance. The extracellular polymeric substance (EPS) matrix acts as a physical and chemical barrier, reducing drug diffusion and stimulating survival pathways....
4. Design Principles of Biofilm-Responsive Prodrugs
Responsive prodrugs are engineered to remain stable in systemic circulation and activate selectively under biofilm-specific conditions such as acidic pH, bacterial enzymes, and redox changes...
4. Design Principles of Biofilm-Responsive Prodrugs
Responsive prodrugs are engineered to remain stable in systemic circulation and activate selectively under biofilm-specific conditions such as acidic pH, bacterial enzymes, and redox changes.
5. Mechanisms of Activation
• pH-sensitive linkers
• Enzyme-cleavable bonds
• Redox-responsive systems
• Quorum sensing modulation
7. Limitations
Synthetic complexity
Stability issues
Scalability & cost
Systemic Circulation
Prodrug (Inactive)
Acidic pH
Biofilm Microenvironment
Bacterial Enzymes
Redox Changes
Quorum Sensing Signals
EPS Matrix
Active Drug
Delivery → Accumulation → Activation → Drug Release
pH
Enzymes
Redox
QS Signals
Active Drug
Prodrug remains stable in circulation and is activated in biofilm by local triggers
→ Release of active antibacterial agent → Antibiofilm effect → Future potentiation
9.1. Experimental Workflow
Synthesis & Characterization
Stability Tests
Activation Studies
Antibiofilm Assays
Cytotoxicity Analysis
Synthesis & Characterization → Stability Tests Activation Cytotoxicity
8. Future Perspectives
Multifunctional systems
Computational design
Smart drug platforms
AI & modeling
Biological validation
9. Proposed Experimental Vaildation
Aim
Evaluate stability, activation, efficacy, Safety
Materials
• Prodrug + Parent Drug
• Bacteria + Cell lines
Methods
Characterization
Activation Studies
Antibiofilm Assays
Cytotoxicity
Expected Results
Selective activation
Enhanced efficacy
Safety + Selectivity
10. Conclusion
Promising strategy
Targeted activation

Figure 2. Conceptual diagram of biofilm-responsive prodrug activation and therapeutic action.

After reaching the infection site in an inactive form, the prodrug is activated by biofilm-related triggers, resulting in local drug release, enhanced antibiofilm activity, and improved therapeutic efficacy.

6. General Principles of Medicinal Chemistry in Biofilm-Responsive Prodrug Design

The development of biofilm-responsive prodrugs requires a comprehensive medicinal chemistry strategy in which chemical stability, selective activation, antibacterial efficacy, and safety are addressed in a coordinated manner. Unlike conventional antibiotic optimization, this approach does not focus solely on enhancing intrinsic antimicrobial potency. Instead, it emphasizes the design of molecular systems capable of remaining sufficiently stable during systemic distribution while undergoing efficient conversion into the active form within the specific microenvironment of a biofilm-associated infection. A central aspect of this design is the careful selection of linkers and promoieties that determine the rate, site, and mechanism of activation. These structural elements must provide a balance between stability under physiological conditions and responsiveness to local triggers such as acidic pH, enzymatic activity, or redox changes. In parallel, the physicochemical properties of the prodrug, including lipophilicity, charge, molecular size, and hydrogen-bonding potential, must be optimized to support diffusion through the biofilm matrix and access to bacterial cells.

Another important consideration is the formation of byproducts during prodrug cleavage. These fragments should ideally be chemically inert, biologically safe, and free from additional toxicological risk. Consequently, the overall effectiveness of a biofilm-responsive prodrug depends not on a single structural modification, but on the successful integration of transport properties, activation kinetics, local selectivity, and pharmacological safety within one rationally designed molecular framework.

7. Therapeutic Applications of Biofilm-Responsive Prodrugs

Biofilm-responsive prodrugs have significant potential in the treatment of infections where conventional antimicrobial therapy often demonstrates limited efficacy. One of the most important application areas is chronic wound infection, in which persistent biofilms contribute to prolonged inflammation, delayed tissue regeneration, and reduced responsiveness to standard antibiotics. In such pathological conditions, local changes in pH, enzymatic activity, and metabolic state create a favorable environment for the selective activation of responsive prodrug systems. Another clinically relevant field is device-associated infection. Biofilms formed on catheters, prosthetic materials, orthopedic implants, and dental devices are especially difficult to eradicate because of their structural stability and reduced susceptibility to antimicrobial agents. In these cases, biofilm-responsive prodrugs may offer an effective strategy by enabling localized drug release directly at the colonized surface, thereby increasing antibacterial concentration at the target site while minimizing systemic exposure.

In addition, pulmonary and other chronic localized infections may benefit from this medicinal chemistry approach. In such settings, the presence of dense biological barriers, persistent microbial communities, and altered local microenvironments often limits the therapeutic performance of free drug molecules. Therefore, responsive prodrug systems represent a promising direction for improving site-selective delivery, overcoming biofilm-related protection, and enhancing the overall effectiveness of anti-infective treatment.

8. Challenges and Translational Limitations

Despite the considerable promise of biofilm-responsive prodrugs, their translation into clinical practice remains associated with several scientific and practical limitations. One of the principal challenges is the heterogeneity of biofilm microenvironments. Variations in pH, enzymatic activity, oxygen availability, redox balance, and metabolic profile across different infection sites make it difficult to design universally effective activation mechanisms. As a result, a prodrug system that performs successfully in one pathological setting may demonstrate limited responsiveness in another. Another important limitation is the insufficiency of conventional antibacterial screening models. Standard in vitro assays based on planktonic bacterial cultures do not adequately reproduce the structural complexity and physiological diversity of mature biofilms. This creates a significant obstacle in the early evaluation of responsive prodrug systems, as their real therapeutic potential may remain underestimated or inaccurately characterized. Consequently, more advanced experimental models are required to assess activation behavior, penetration efficiency, and antibacterial performance under biofilm-relevant conditions. In addition, issues related to safety, manufacturing, and regulatory approval must also be taken into consideration. Since biofilm-responsive prodrugs function as dynamic chemical systems, their development requires careful evaluation of stability, release kinetics, byproduct formation, and possible off-target activation. These factors increase both the complexity of formulation and the difficulty of regulatory assessment. Therefore, although this strategy is scientifically attractive, its successful implementation depends on the integration of medicinal chemistry innovation with realistic biological modeling and translational feasibility [8, p.11,11, p.2113].

9. Future Perspectives

The future development of biofilm-responsive prodrugs is likely to depend on the integration of medicinal chemistry with microbiology, materials science, and advanced computational approaches. Further progress in this field will require a deeper understanding of the chemical and biological characteristics of biofilm microenvironments, including local pH variations, enzyme expression patterns, redox conditions, and metabolite distribution. Such knowledge will make it possible to design prodrug systems with greater selectivity and improved activation efficiency.

Another important perspective is the creation of multifunctional prodrug platforms capable of combining several therapeutic effects within a single molecular design. In addition to the release of an active antibacterial agent, future systems may incorporate biofilm-disrupting components, quorum-sensing inhibitors, or antivirulence elements in order to overcome microbial protection more effectively. This would allow medicinal chemistry to move beyond conventional bactericidal action toward more complex and targeted therapeutic strategies. The application of computational modeling, molecular simulation, and artificial intelligence may also play an increasingly important role in the optimization of responsive prodrugs. These tools can support the rational selection of linkers, prediction of activation behavior, and evaluation of structure–property relationships before experimental synthesis. Therefore, the future of this field lies not only in the discovery of new antibacterial scaffolds, but also in the development of intelligent, microenvironment-directed molecular systems capable of improving the precision and effectiveness of anti-infective therapy.

10. Proposed Experimental Validation of Biofilm-Responsive Prodrug Systems. 10.1. Aim of the Experimental Study

The proposed experimental study is intended to evaluate the practical potential of biofilm-responsive prodrug systems as selective antibacterial agents for biofilm-associated infections. The main objective is to determine whether the designed prodrug candidates remain sufficiently stable under physiological conditions, undergo activation in biofilm-relevant environments, and demonstrate stronger antibiofilm performance than the corresponding parent drug. In addition, the study

aims to assess the selectivity and biological safety of the designed systems in order to establish their potential value for future medicinal chemistry research [7, p.976].

10.2. Materials

The experimental design may include synthesized biofilm-responsive prodrug candidates based on a selected antibacterial parent compound, together with the corresponding free drug for comparative evaluation. Standard buffer solutions of neutral and mildly acidic pH may be used to simulate systemic and infection-associated environments. Depending on the selected activation mechanism, bacterial enzymes or reducing agents may be included as trigger factors in the activation studies. For biological testing, representative biofilm-forming bacterial strains such as *Pseudomonas aeruginosa, Staphylococcus aureus*, and *Escherichia coli* may be employed. These microorganisms are widely recognized as clinically relevant pathogens in chronic and device-associated infections. In addition, mammalian cell lines may be used for cytotoxicity assessment in order to examine the safety profile of the designed prodrug systems.

10.3. Methods

The first stage of the study should involve structural and physicochemical characterization of the synthesized prodrug candidates. Their purity, identity, and chemical stability may be confirmed by appropriate analytical techniques. Special attention should be paid to their stability in physiological media and to their behavior in conditions simulating the biofilm microenvironment. The second stage should focus on activation studies. The prodrug candidates may be incubated under different trigger conditions, such as acidic pH, enzyme-containing media, or reducing environments, depending on the nature of the responsive linker. The release of the active parent drug may then be monitored using suitable analytical methods. This step is essential for confirming that activation occurs selectively under biologically relevant conditions [3, p.264].

At the biological evaluation stage, antibacterial activity should be assessed not only against planktonic bacterial cells but also against established biofilms. Particular emphasis should be placed on biofilm inhibition and biofilm eradication experiments. The effectiveness of the prodrug systems may be evaluated through measurements of biofilm biomass, viable cell counts, and microscopic analysis of biofilm architecture. A direct comparison with the free parent drug would allow the real contribution of the prodrug design to be determined. Finally, cytotoxicity assessment should be performed to evaluate whether the prodrug candidates and their cleavage products remain within acceptable safety limits. The comparison of activation behavior in infection-mimicking conditions and in normal physiological media would also help define the selectivity of the system [6, p.27]

10.4. Expected Results and Scientific Significance

It is expected that the biofilm-responsive prodrug candidates will remain relatively stable under physiological conditions while showing enhanced activation in the presence of biofilm-related triggers. As a result, these systems may demonstrate improved local release of the antibacterial agent, greater inhibition of biofilm formation, and more effective disruption of mature biofilms when compared with the parent drug alone. From a medicinal chemistry perspective, such findings would confirm the value of responsive molecular design as a strategy for overcoming one of the major limitations of conventional antibiotics in persistent infections. The proposed experimental model would therefore serve not only as a validation framework for the concepts discussed in this article, but also as a basis for future research aimed at the development of more selective, efficient, and biologically relevant antibacterial systems [12, p.139].

11. Conclusion

Biofilm-associated infections continue to represent one of the most serious challenges in contemporary anti-infective therapy, particularly under conditions of increasing antimicrobial resistance. The limited success of many conventional antibiotics in biofilm environments demonstrates that effective treatment depends not only on antibacterial potency, but also on the ability of a therapeutic system to penetrate the biofilm matrix, remain stable during transport, and release the active agent selectively within the infected microenvironment. In this context, biofilm-responsive prodrug design represents a promising and conceptually advanced direction in medicinal chemistry. By linking drug activation to local physicochemical and biological triggers, this strategy offers new possibilities for improving site-selective delivery, reducing systemic toxicity, and enhancing antibiofilm efficacy. The discussion presented in this article shows that such systems have strong theoretical value and may contribute to the development of more adaptive and targeted antibacterial therapies.

At the same time, the proposed experimental validation framework highlights the practical importance of connecting molecular design with measurable biological performance. The evaluation of chemical stability, trigger-responsive activation, antibiofilm activity, and safety is essential for transforming this concept from a theoretical model into an experimentally supported medicinal chemistry approach. Therefore, the future significance of biofilm-responsive prodrugs will depend not only on innovative structural design, but also on the successful integration of experimental evidence, biological relevance, and translational feasibility. Overall, biofilm-responsive prodrugs may become an important component of next-generation strategies against persistent and resistant infections. Their further development has the potential to expand the boundaries of medicinal chemistry by introducing more selective, microenvironment-oriented, and functionally intelligent therapeutic systems.

References

1. Chen, D., Li, D., Su, L., Wang, D.-Y., Ren, Y., van der Mei, H. C., Shi, L., Chen, T., & Busscher, H. J. Stimuli-responsive, antimicrobial-loaded nanocarriers for oral biofilm control and microbiome restoration. International Journal of Oral Science, 2026, 18(1), 17. https://doi.org/10.1038/s41368-025-00422-3.

2. Coenye, T., Bové, M., & Bjarnsholt, T. Biofilm antimicrobial susceptibility through an experimental evolutionary lens. NPJ Biofilms and Microbiomes, 2022, 8(1), 82. https://doi.org/10.1038/s41522-022-00346-4

3. Kalia, V. C., Patel, S. K. S., & Lee, J.-K. Bacterial biofilm inhibitors: An overview. Ecotoxicology and Environmental Safety, 2023, 264, 115389. https://doi.org/10.1016/j.ecoenv.2023.115389.

4. Kamath, S., Ariaee, A., Abdelhafez, A., Asif, Z., Chan, N. S. L., Collins, K., Hunter, A., & Joyce, P. Microbiome-active drug delivery systems (MADDS): Leveraging microbial stimuli for controlled drug release. Advanced Drug Delivery Reviews, 2025, 227, 115720. https://doi.org/10.1016/j.addr.2025.115720.

5. Li, G.-W., Liang, K.-H., Zhang, W., Rao, G.-W., & Zheng, Q. Novel strategies targeting biofilms: A review of the structure-activity relationships of quorum sensing inhibitors. Journal of Molecular Structure, 2026, 1359, 145416. https://doi.org/10.1016/j.molstruc.2026.145416.

6. Liu, H. Y., Prentice, E. L., & Webber, M. A. Mechanisms of antimicrobial resistance in biofilms. NPJ Antimicrobials and Resistance, 2024, 2(1), 27. https://doi.org/10.1038/s44259-024-00046-3.

7. MubarakAli, D., Saravanakumar, K., Ganeshalingam, A., et al. Recent progress in multifunctional stimuli-responsive combinational drug delivery systems for the treatment of biofilm-forming bacterial infections. Pharmaceutics, 2024, 16(8), 976. https://doi.org/10.3390/pharmaceutics16080976.

8. Wu, Z., Nie, R., Wang, Y., Wang, Q., Li, X., & Liu, Y. Precise antibacterial therapeutics based on stimuli-responsive nanomaterials. Frontiers in Bioengineering and Biotechnology, 2023, 11, 1289323. https://doi.org/10.3389/fbioe.2023.1289323.

9. Yang, S., Li, X., Cang, W., Mu, D., Ji, S., An, Y., Wu, R., & Wu, J. Biofilm tolerance, resistance and infections increasing threat of public health. Microbial Cell, 2023, 10(11), 233–247. https://doi.org/10.15698/mic2023.11.807.

10. Zafer, M. M., Mohamed, G. A., Ibrahim, S. R. M., Ghosh, S., Bornman, C., & Elfaky, M. A. Biofilm-mediated infections by multidrug-resistant microbes: a comprehensive exploration and forward perspectives. Archives of Microbiology, 2024, 206(3), 101. https://doi.org/10.1007/s00203-023-03826-z.

11. Zhang, J., Tang, W., Zhang, X., Song, Z., & Tong, T. An overview of stimuli-responsive intelligent antibacterial nanomaterials. Pharmaceutics, 2023, 15(8), 2113. https://doi.org/10.3390/pharmaceutics15082113.

12. Zhang, R., Lin, H., Wang, Z., Cheng, S., Li, C., & Wang, Y. Research progress on antimicrobial biomaterials. Macromolecular Bioscience, 2025, 25(9), 139. https://doi.org/10.1002/mabi.202500239.

ECONOMIC SCIENCES

FEATURES OF BULGARIA'S INNOVATION ACTIVITY (2019–2023)

Ivanova R.P.
Assoc. Professor, Ph.D.
University of Economics – Varna
Web of Science: Researcher ID JBJ-6290-2023
ORCID: https://orcid.org/0000-0001-9554-0349
DOI: 10.5281/zenodo.19327221

ABSTRACT

Innovation and the innovation activity of economic entities are of decisive importance for the level of development of every country and every region. The continuous shortening of product life cycles and the accelerated renewal of needs further reinforce the necessity of constant innovation. At the core of seeking and finding new ways, methods, and means of improving the competitive advantages of organizations lies in research and development (R&D), which is also the foundation of innovation. In this regard, at EU level, an expenditure benchmark has been set relative to the GDP of each country as well as the EU average.

The purpose of this article is to analyze the level of innovation and innovation activity of organizations in Bulgaria, as well as the country's position in regional and global rankings.

Keywords: innovation, innovation-active enterprises, R&D, Bulgaria.

INTRODUCTION

Innovation is an inseparable part of progress and the socio-economic growth of every country today. Focusing the attention of organizational leaders from all sectors of the economy on innovation and laying the foundation for stimulating its development is of primary importance for success at all levels – organizational, regional, national, and international.

Therefore, innovations and innovation processes are among the main factors subject to constant monitoring and analysis (V. Manolov, 2017, p. 51). They are also at the center of EU policies.

THEORETICAL FRAMEWORK

The term *innovation* today is part of the everyday vocabulary of individuals, private and public sector organizations, national governments, and supranational bodies such as the EU, EC, NATO, etc. There are numerous studies in the field of innovation, with the earliest reference dating back to the reign of King Edward VI, who used the term in 1548 to describe changes in nature or fashion as a new practice, method, etc. From a scientific standpoint, the modern meaning of the term was introduced by Joseph Schumpeter in 1934 (V. Manolov, 2016, p. 477). Later researchers provided their own interpretations, but the common element in all of them is *novelty*, which must be present regardless of the perspective. Today, we understand innovation as any new or improved product or service introduced on the market, a new or improved process, technology, organizational work method, or a new way of exploiting end products. Novelty can be considered from the perspective of organizations, markets, consumers, or the sector where it appears. The variety of interpretations of innovation has led to the use of different approaches in clarifying its essence – static, dynamic, and interactive (R. Ivanova, 2021, p. 12). Creating innovation presupposes the implementation of R&D, financial, production, and commercial activities, the entirety of which constitutes innovation activity. This activity has a complex and multifaceted character, encompassing a wide range of novelties (P. Vitleemov et al., 2014, p. 70).

At the heart of innovation lies human creativity and creative thinking, which are in direct connection with scientific knowledge and technological achievements in every field of activity. In turn, systematic work aimed at increasing knowledge and culture, as well as discovering new applications of already known knowledge, forms the essence of research and development (R&D) (nsi.bg). The existence of R&D enables innovation activity. However, investment in R&D alone does not ensure economic growth – it must be connected with concrete activities for implementing results in the real organizational transformation process. This is characterized by uncertainty and accompanied by the risk of failure, due to the impossibility of predicting outcomes with precision. For this reason, some researchers argue that generating new ideas and deriving real benefits from them depends on the ability of companies and their components to focus on transforming a new idea into an innovation (V. Manolov, 2016, p. 480). A key feature of innovation is its successful market realization.

The extent of innovation in organizations can be seen as both a result of changes in the economic environment and as a driver of significant changes within organizations themselves. This determines the level of innovation activity. Practice shows that organizations must accept the need for continuous generation of new ideas, as this ensures stronger competitive positions. It is also important to pay attention to new knowledge and to orient thinking not only toward satisfying existing needs, but also toward predicting future ones (V. Manolov, 2017, p. 52). In this respect, some researchers link innovation to the introduction of creative ideas into practice, leading to profit generation (Zhelev et al., 2014, p. 99).

The relevance of innovation activity is further highlighted by the specially developed strategies for each EU programming period – the Innovation Strategy for Smart Specialization (ISSS). The first ISSS for Bulgaria, developed for the 2014–2020 period, aimed to help the country transition from the group of "modest

(emerging) innovators" to the group of "moderate innovators." The strategy focused on four priority areas: (1) Informatics and ICT, (2) Mechatronics and clean technologies, (3) Healthy lifestyle industries and biotechnology, (4) New technologies in creative and recreational industries.

The ISSS 2021–2027 builds on the results of the previous stage and reflects new EU policies in line with the opportunities and socio-economic challenges facing Bulgaria and other countries in the region. Analysis of the 2014–2020 period shows that unfortunately, Bulgaria did not achieve its ISSS goals in the field of innovation. The country remains faced with obstacles that prevent it from fully utilizing its potential and opportunities to improve its innovation performance above 70% of the EU average – the threshold for joining the "moderate innovators" group. It must be noted that in Bulgaria effective interaction between science, government, and business has not yet been achieved to create a functioning innovation ecosystem. Such an ecosystem would require synchronized policies enabling R&D development, providing a favorable basis for innovation.

Furthermore, ISSS 2021–2027 directs the attention of EU countries, including Bulgaria, to the implementation of the cohesion policy *"A Smarter Europe through innovation and support for economic transformation and modernization"* (ISSS 2021–2027, p. 6). For Bulgaria, five priority areas of development have been identified, reflecting the country's competitive advantages and development capacity: (1) Informatics and ICT, (2) Mechatronics and microelectronics, (3) Healthy lifestyle industries, (4) New technologies in creative and recreational industries, (5) Clean technologies, circular and low-carbon economy. An important new feature compared to the previous programming period is the separate inclusion of mechatronics and microelectronics, driven by Bulgaria's demonstrated potential in automation and robotics, intelligent manufacturing systems, artificial intelligence, and integrated circuit design and application. These areas underpin digitalization and smart transformation, which are key goals regionally and globally. In addition, there is a growing emphasis on the circular economy and sustainable development.

METHODOLOGY

To analyze the state of innovation activity and the degree of innovation performance in Bulgaria, officially published statistical data have been used from the National Statistical Institute (NSI), the Ministry of Innovation and Growth in Bulgaria, Innovation.bg, Eurostat, the European Innovation Scoreboard, and the Global Innovation Index. This ensures both easy access to information and the reliability of the data. The statistical data allow for greater precision in comparative analysis and in identifying trends in the examined field, which can then be visualized through charts. Given the time required for collecting, summarizing, and publishing data by NSI and Eurostat, the analyzed period is 2019–2023, which does not diminish the relevance of the conclusions drawn.

RESULTS AND DISCUSSION

The implementation of innovation activity is closely linked to R&D and, respectively, to the funds invested in it. Reported data on expenditures as a share of GDP show that in Bulgaria there has been a decline during the 2019–2023 period (see Fig. 1). The level of these expenditures is significantly below the targets set in the country's Innovation Strategies for Intelligent Specialization (ISSS), both for the previous and current programming periods. The planned R&D expenditure level in Bulgaria is 1.5% of GDP, while for the EU this target is 3%. The reason for this difference lies in the consideration of the specific economic conditions of each member state.

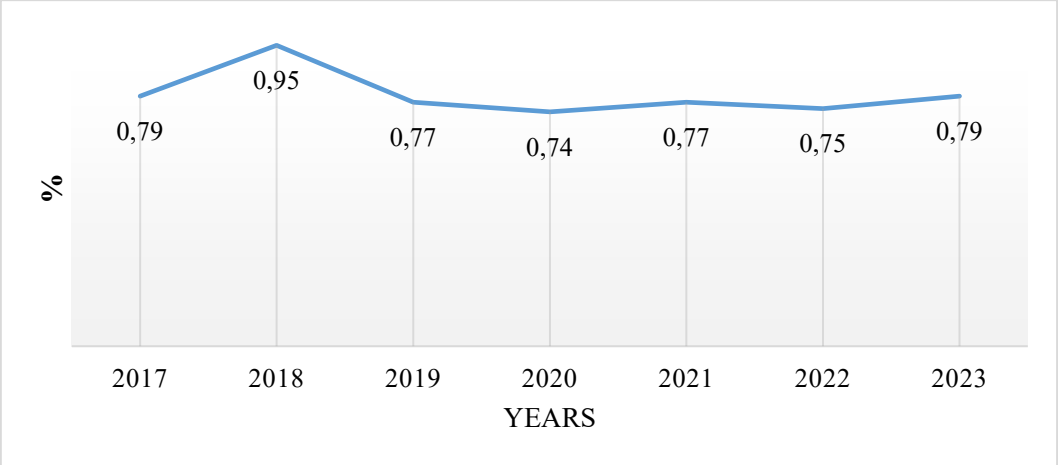


Fig. 1. Relative share of R&D expenditure in Bulgaria as a percentage of GDP (2017–2023)

As of 2023, the reported R&D expenditure in Bulgaria represents only half of the planned relative share compared to the country's GDP.

The analysis of the absolute amount of funds invested in R&D in Bulgaria, broken down by enterprise size, shows growth – from BGN 673,122 in 2019 to BGN 943,747 in 2023. A continuous increase is observed only among large enterprises, while micro, small, and medium-sized enterprises show fluctuations – periods of decline alternate with periods of growth. The lowest level of R&D expenditure among them was recorded in 2021. In the following two years, however, these enterprises also reported growth (see Fig. 2).

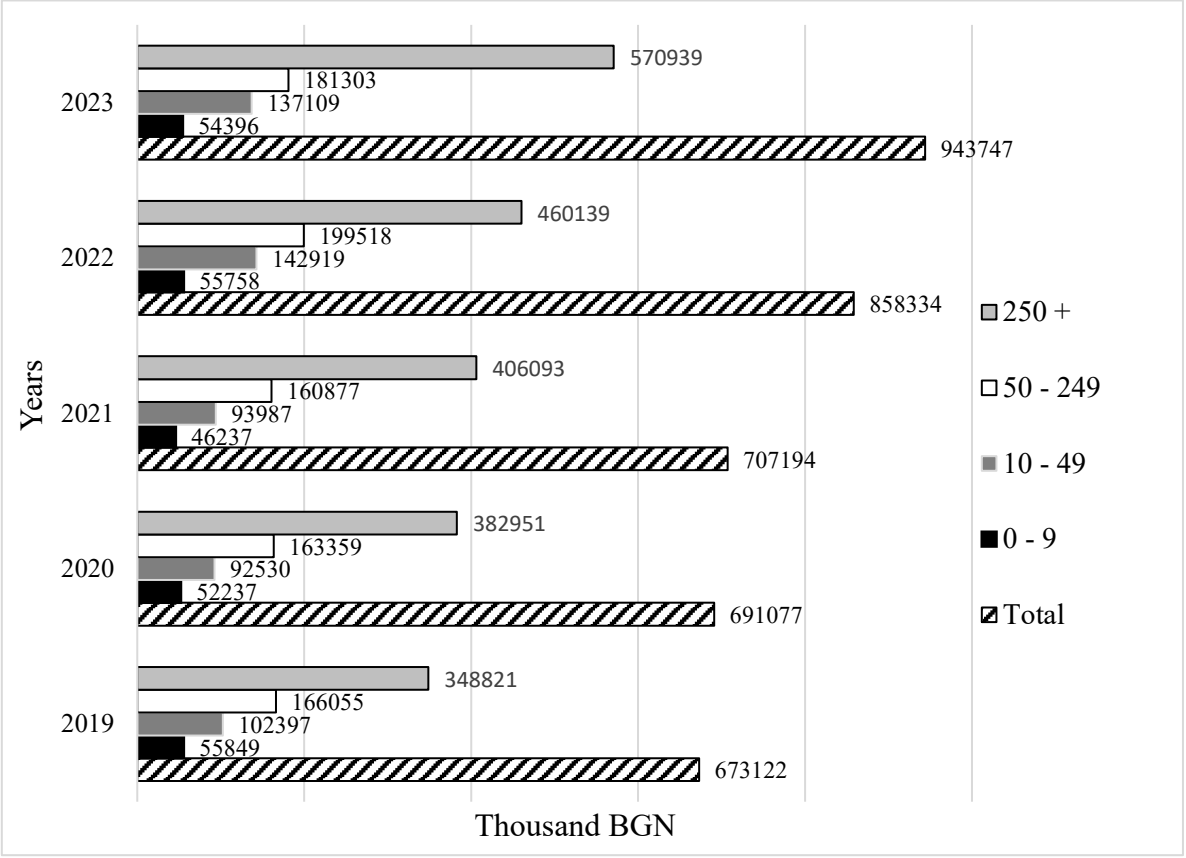


Fig. 2. R&D expenditure by enterprise size in Bulgaria (2019–2023)

The monitoring of state expenditures for R&D shows a steady increase in their absolute value for the period 2019–2024. By 2024, these expenditures are more than 1.8 times higher compared to 2019 (see Fig. 3). This can be regarded as a favorable trend, indicating an increased focus of the state on this sector.

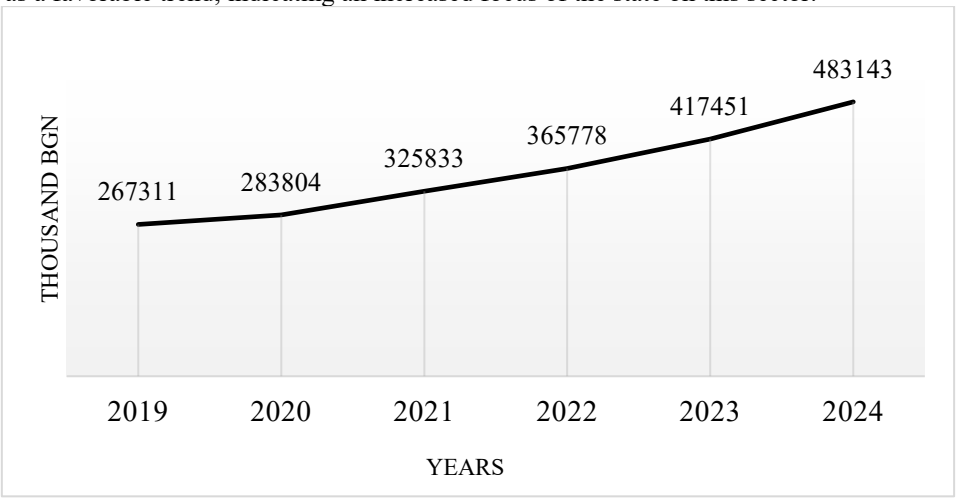


Fig. 3. Dynamics of government R&D expenditure in Bulgaria (2019–2024)

From the perspective of funding sources, enterprise expenditures on R&D are the largest, followed by the public sector. Expenditures in the Higher Education sector are significantly lower, while those in the nonprofit sector can be considered negligible (see Fig. 4).

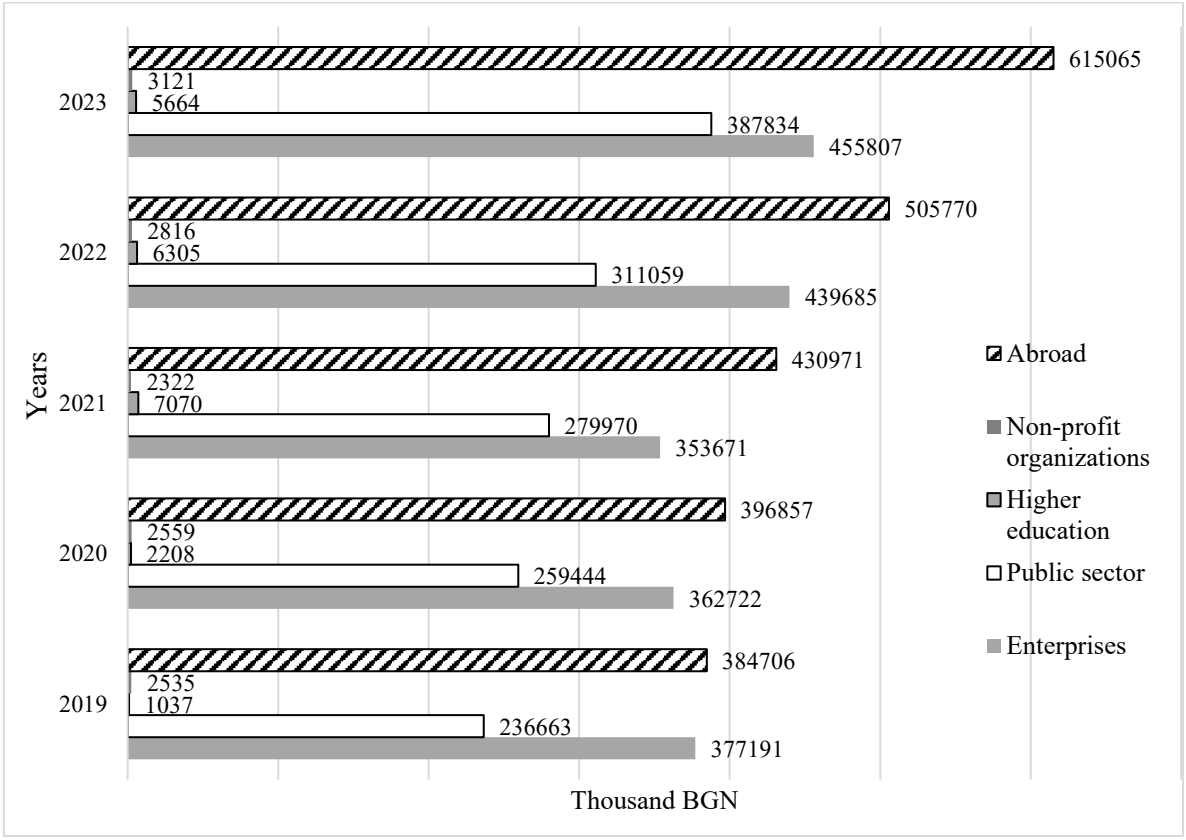


Fig. 4. R&D expenditure by funding sources and sectors in Bulgaria (2019–2023)

The degree of innovation development in a country is strongly influenced by the number of innovation-active enterprises, as a higher number implies a larger volume of innovations. This group includes enterprises that regularly engage in activities related to developing and introducing new or improved products, services, and processes during the reporting period. An important characteristic is that such enterprises do not have a specific organizational-legal form (N. Taneva, D. Dimov 2007, p. 431). Therefore, this group includes diverse entities. In Bulgaria, the relative share of innovation-active enterprises for the period 2018–2022 shows an unfavorable trend, resulting in a lower share in 2022 compared to the beginning of the period. Structurally, from the perspective of economic activities, industry has consistently had more innovation-active enterprises compared to the services sector (see Fig. 5).

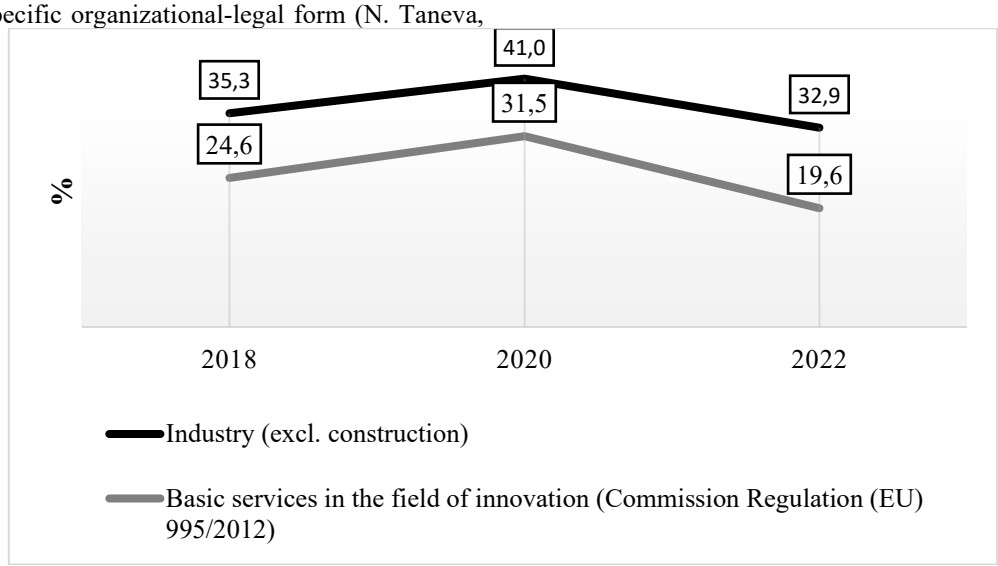


Fig. 5. Share of innovation-active enterprises of total enterprises in Bulgaria by economic activity (2018–2022)

From the perspective of enterprise size, large enterprises (with more than 250 employees) account for over 70% of all innovation-active enterprises in each of the years in the reviewed period. This is a logical trend, as larger organizations have more opportunities and free resources to allocate to R&D and innovation activities. At the same time, only about 1/5 of small enterprises (10–49 employees) fall into the innovation-active group (see Fig. 6).

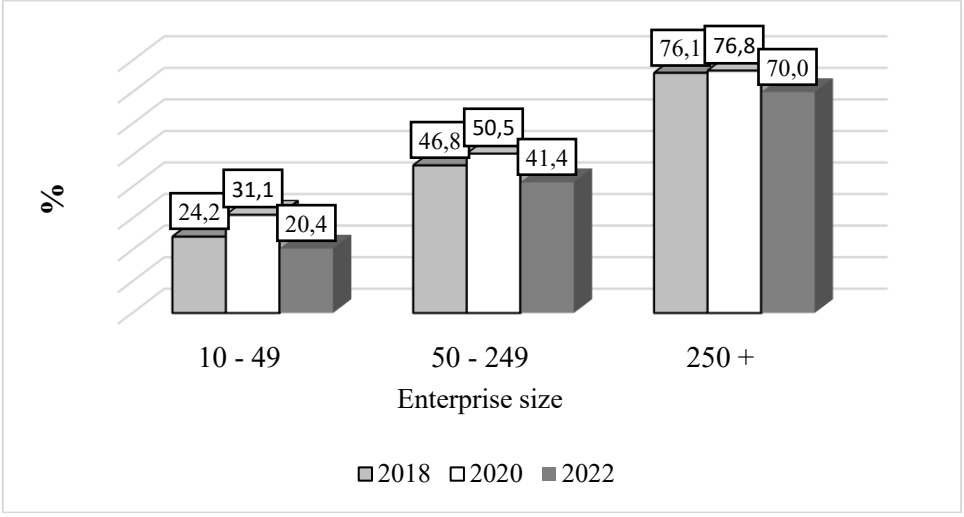


Fig. 6. Share of innovation-active enterprises of total enterprises in Bulgaria by enterprise size (2018–2022)

In recent years, cooperation among organizations in joint innovation projects—i.e., innovation collaboration—has become increasingly important. The analysis of statistical data shows that the relative share of enterprises engaged in innovation cooperation in Bulgaria grew between 2018–2022, regardless of enterprise size or economic activity (see Fig. 7 and 8).

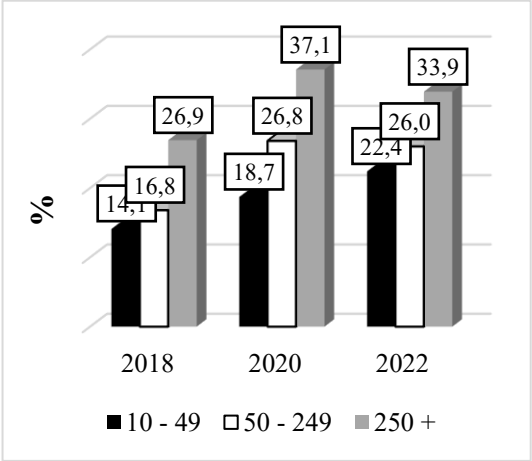


Fig. 7. Share of enterprises with innovation cooperation of total innovation-active enterprises in Bulgaria by enterprise size (2018-2022)

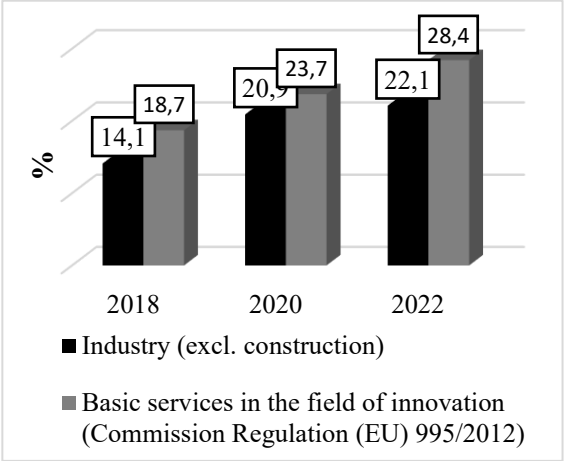


Fig. 8. Share of enterprises with innovation cooperation of total innovation-active enterprises in Bulgaria by economic activity (2018-2022)

At the same time, despite the growth, organizations engaged in innovation cooperation represent only about one-third of all innovation-active enterprises. This can be regarded as an unfavorable trend, requiring suitable corrective measures. One factor behind the lack of interest in developing innovation activity is the absence of proper legal frameworks to stimulate it, including the lack of an Innovation Act, special incentives, etc.

On the other hand, the level of innovation and innovation activity should not be considered only from a national perspective (K. Semova 2021, p. III-25). At the European level, the European Innovation Scoreboard (EIS) clearly shows Bulgaria's lag in innovation. In 2024, Bulgaria remains in 33rd place among EU and neighboring countries, and second-to-last among EU member states (EIS 2024, p. 72). According to the Global Innovation Index 2024, Bulgaria ranks 38th among 133 countries (GII 2024, p. 18). Improvements were reported only in three areas: the level of employment in innovation-active enterprises; the relative share of foreign PhD students compared to the total number of PhD students in Bulgaria; and the expanding access to broadband internet, which plays a crucial role in digitalization (Innovation.bg 2024, p. 25).

In this context, it must be noted that the number of PhD students with Bulgarian citizenship is decreasing, while the number of foreign PhD students is increasing (see Fig. 9).

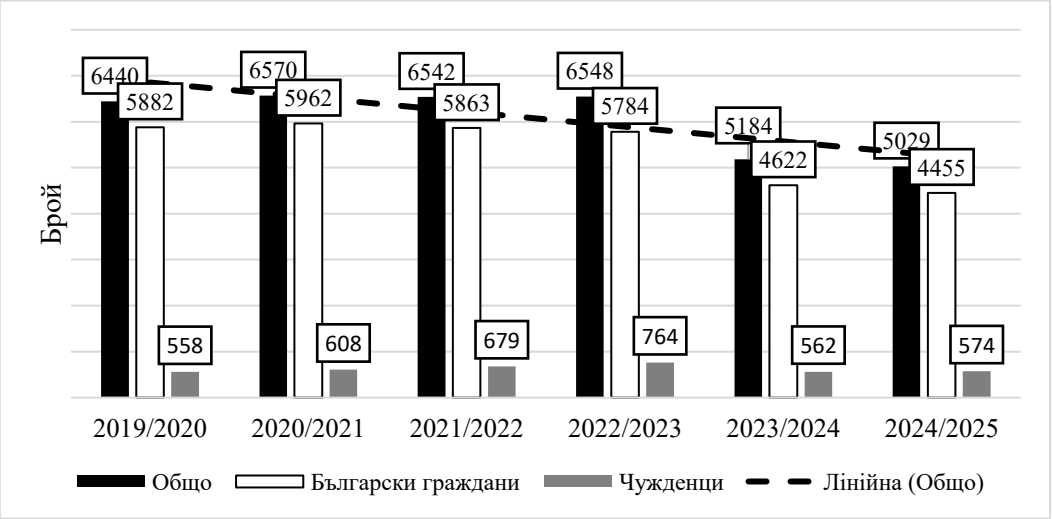


Fig. 9. Dynamics of total PhD student enrollment in Bulgaria by academic year (2019–2025)

An increase in the second year compared to the beginning of the period is followed by a slight decline, and by the end of the period, there is a sharp drop in total PhD enrollments. The relative share of foreign students rises from 8.66% in the 2019/20 academic year to 10.84% in 2023/24, and 11.41% according to the data for 2024/25. This can be viewed positively in terms of growing foreign interest, but the declining participation of Bulgarian students is a negative trend. Furthermore, attention should be paid to the share of PhD students who successfully complete their studies. Data show that this share is relatively low (see Fig. 10). The reasons for this may vary, including the fact that the Higher Education Act in Bulgaria allows PhD students who meet certain criteria to be deregistered with the right to defend within five years, while there is no mechanism obliging them to actually defend their dissertation, even for those studying under a state-funded position. The lack of sanctions, combined with the relatively high amount of the scholarship for full-time study during three years, serves as a good incentive for applicants to enroll in the academic degree "Doctor". However, the low number of students who ultimately obtain a doctoral degree is problematic for the universities training them and negatively affects their accreditation evaluation by the National Evaluation and Accreditation Agency (NEAA) in Bulgaria.

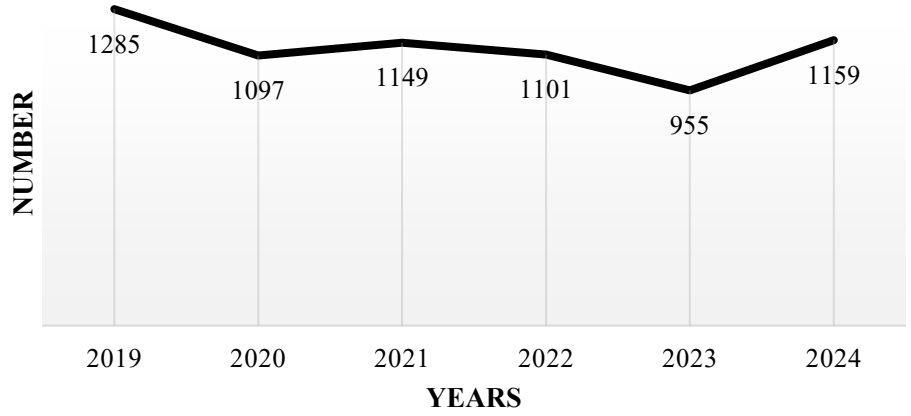


Fig. 10. Dynamics of successfully defended PhD degrees in Bulgaria (2019–2024)

There is a clear downward trend in the number of students awarded PhD degrees during 2019–2024. A detailed analysis is needed to determine the reasons behind these results and to take appropriate measures.

The ICT sector in Bulgaria shows accelerated growth, with an increasing number of employees and rising exports of high-tech new products. However, the rising share of registered trademarks and industrial designs at the Patent Office indicates that Bulgaria's competitive advantages lie more in low-tech intellectual property. Together with insufficient digitalization, despite improved broadband access, this can be considered an unfavorable trend. More efforts are needed to stimulate the development of sectors where Bulgaria has potential for stronger regional and global positioning.

CONCLUSION

Innovation activity is among the key priorities of all EU member states. Strategies in this field take into account the current state of each economy and set targets to be achieved within the respective programming period. For Bulgaria, the main goal in the current ISSS is to transform the country into a "moderate innovator,"

although it continues to remain in the group of "emerging innovators." Therefore, efforts by all stakeholders – state, business, NGOs, and educational institutions – must be intensified to generate enough new ideas and transform them into innovations of various types and applications, in order to adequately meet the expectations of the EC and the EU as a whole. Appropriate instruments must be developed to stimulate innovation, as well as stronger cooperation between the state, science, and business. The primary goal is both to support R&D implementation and to ensure broader access to innovations, enabling organizations to improve their performance and ensuring Bulgaria's overall development in the field of innovation.

References

1. European Innovation Scoreboard – 2024. (2024). Brussels: European Commission.

2. Global Innovation Index 2024. Unlocking the Promise of Social Entrepreneurship. (2024). WIPO, 17th Edition.

3. Innovation.BG: Inovatsii i ustoychivost za badesht rastezh. (2024). Sofiya: Fondatsiya „Prilozhni izsledvaniya i komunikatsii".

4. Innovation Strategy for Smart Specialisation 2021-2027. Sofia: Ministerstvo na inovatsiite i rastezha.

5. Ivanova, R. (2021). Upravlenie na inovatsiite. Uch.pos. Varna: „Nauka i ikonomika"

6. Manolov, V. (2017). The Innovation Potential of Small and Medium Enterprises. The Barriers in Transforming Knowledge into Economic Activity. Strategies for Policy in Science and Education. Vol. 25, Number 1, 2017, pp. 51-63.

7. Manolov, V. (2016). The Innovation in Small and Medium Sized Enterprises as a Strategic Goal of the Scientific Policy of the EU: Towards a Model of Intelligent Enterprise. Strategies for Policy in Science and Education. Vol. 24, Number 5, 2016, pp. 476-491.

8. Semova, K. (2021). Otsenka na inovatsionnata aktivnost v transportniya sektor i vazmozhnosti za neynoto nasarchavane – problemi i resheniya. Mehatronika, Transport, Komunikatsii. tom 10, br. 1, statiya №2164, s. III-24-III-29.

9. Spravka za inovatsionnata deynost na predpriyatieto prez perioda 2022 - 2024 godina. https://www.nsi.bg/sites/default/files/files/pages/GOD2024/P5/26_%D0%A1%D0%9F%D0%A0%D0%90%D0%92%D0%9A%D0%90%20%D0%97%D0%90%20%D0%98%D0%9D%D0%9E%D0%92%D0%90%D0%A6%D0%98%D0%9E%D0%9D%D0%9D%D0%90%D0%A2%D0%90%20%D0%94%D0%95%D0%99%D0%9D%D0%9E%D0%A1%D0%A2%20%D0%9D%D0%90%20%D0%9F%D0%A0%D0%95%D0%94%D0%9F%D0%A0%D0%98%D0%AF%D0%A2%D0%98%D0%95%D0%A2%D0%9E%20%D0%9F%D0%A0%D0%95%D0%97%20%D0%9F%D0%95%D0%A0%D0%98%D0%9E%D0%94%D0%90%202022%20-%202024%20%D0%93%D0%9E%D0%94%D0%98%D0%9D%D0%90.pdf

10. Taneva, N., D. Dimov. (2007). Essence and characteristics of innovative enterprises. 5th International Scientific Conference "Management and Engineering '07". Sozopol, Bulgaria. Volume: ISSN 1310-3946; pp. 431-434.

11. Vitliemov, P., M. Peeva, V. Vitliemov. (2014). Inovatsionnata deynost – baza za predpriemacheskite protsesi v industrialnoto proizvodstvo. Nauchni trudove na RU. Tom 53, seriya 2, s. 70-77.

12. Zhelev, Ya., A. Toshkov, E. Nikolova, M. Zheleva. (2014). Razvitie na ikonomika, bazirana na znaniya i inovatsii chrez izgrazhdane na Ofis za Tehnologichen Transfer: Neobhodimost, kontseptualen model i logicheska ramka. Biznes posoki, Burgas: BSU, br. 2, s. 99-108.

PEDAGOGICAL SCIENCES

METHODOLOGICAL FOUNDATIONS FOR FORMING ECOLOGICAL AWARENESS IN TEACHING THE TOPIC "TYPES OF FUEL AND THE ENVIRONMENT"

Mammadzade G.,
Master's Student, Azerbaijan State Pedagogical University, Baku, Azerbaijan
Babayeva N.
Senior Lecturer, PhD in Chemistry, Azerbaijan State Pedagogical University, Baku, Azerbaijan
DOI: 10.5281/zenodo.19327244

ABSTRACT

The teaching of chemistry in modern schools is expected not only to develop students' scientific knowledge but also to cultivate ecological awareness and responsible attitudes toward the environment. In this context, the topic "Types of Fuel and the Environment" has significant educational potential, since it directly connects chemical concepts with everyday life, energy use, air pollution, climate change, and sustainable development. The present article examines the methodological foundations for forming ecological awareness during the teaching of this topic. It emphasizes that the effective teaching of fuels should be based on interdisciplinary integration, problem-based learning, contextual instruction, experimental activities, and value-oriented discussion.

The article analyzes the pedagogical possibilities of comparing traditional and alternative fuels, exploring the chemical nature of combustion, and evaluating the environmental consequences of fuel consumption. Special attention is given to methods that help students move from simple knowledge acquisition to ecological thinking, critical evaluation, and responsible decision-making. The study concludes that the topic "Types of Fuel and the Environment" can serve as an important means of integrating chemistry education with environmental education, thereby contributing to the formation of scientifically literate and environmentally conscious students.

Keywords: Chemistry teaching, ecological awareness, fuel types, environmental education, methodological foundations, sustainable development, school chemistry.

INTRODUCTION

In contemporary education, the role of chemistry extends beyond the transmission of theoretical knowledge. Chemistry teaching is increasingly viewed as a means of helping students understand the natural world, interpret human impact on the environment, and make informed decisions in daily life. One of the most meaningful topics in this regard is "Types of Fuel and the Environment," because it links chemical knowledge with global ecological issues such as air pollution, greenhouse gas emissions, resource depletion, and energy sustainability.

Fuel is an integral part of human civilization. Coal, oil, natural gas, biomass, and alternative energy carriers have played a central role in industrial development, transport, domestic life, and economic growth. At the same time, the extraction, processing, and combustion of fuels have led to serious environmental consequences. The emission of carbon dioxide, sulfur oxides, nitrogen oxides, and particulate matter contributes to atmospheric pollution, acid rain, and climate-related problems. Therefore, the chemistry lesson devoted to fuels should not be limited to classification and combustion equations. It should also become a space where students develop ecological awareness, evaluate environmental risks, and reflect on sustainable energy choices. This article explores the methodological foundations of forming ecological awareness in teaching the topic "Types of Fuel and the Environment." It aims to show how chemistry teachers can organize this topic in a way that strengthens both scientific understanding and environmental responsibility [1, p1847,11, p.1357].

The Educational Potential of the Topic

The topic "Types of Fuel and the Environment" occupies a special place in school chemistry because it combines subject knowledge with socially significant content. From a chemical perspective, students study the composition of fuels, calorific value, combustion processes, oxidation reactions, and the products of complete and incomplete combustion. From an ecological perspective, they encounter problems related to atmospheric pollution, carbon emissions, toxic gases, and the environmental consequences of fossil fuel dependence.

This dual character gives the topic considerable pedagogical value. It allows the teacher to demonstrate that chemistry is not an abstract science isolated from life, but a practical discipline that explains real environmental processes. When students examine why different fuels burn differently, why some release more pollutants, or why cleaner technologies are being promoted, they begin to connect chemical theory with contemporary ecological challenges. Another important advantage of the topic is that it encourages discussion. Students can compare household fuels, transportation fuels, and industrial fuels; analyze the advantages and disadvantages of traditional and renewable energy sources; and consider how individual and collective choices affect the environment. Such discussions strengthen not only cognitive understanding but also value-based reflection[13, p.2743,12, p.44].

Ecological Awareness as a Pedagogical Goal

Ecological awareness is a complex educational outcome. It includes knowledge about environmental processes, understanding of the causes and consequences of ecological problems, emotional sensitivity

to environmental damage, and readiness to act responsibly. In chemistry education, ecological awareness should not emerge accidentally. It must be formed through purposeful instructional design. When teaching fuels, ecological awareness develops most effectively if students are guided to answer several essential questions: What happens chemically during combustion? Which fuels are more harmful to the environment and why? What pollutants are formed? How do fuel choices influence human health and climate? What alternatives exist, and what are their advantages and limitations?

Such questions shift the focus from memorization to understanding. Students begin to see that the issue is not only which fuel gives more energy, but also what ecological price is paid for that energy. In this way, chemistry teaching becomes a platform for responsible thinking.

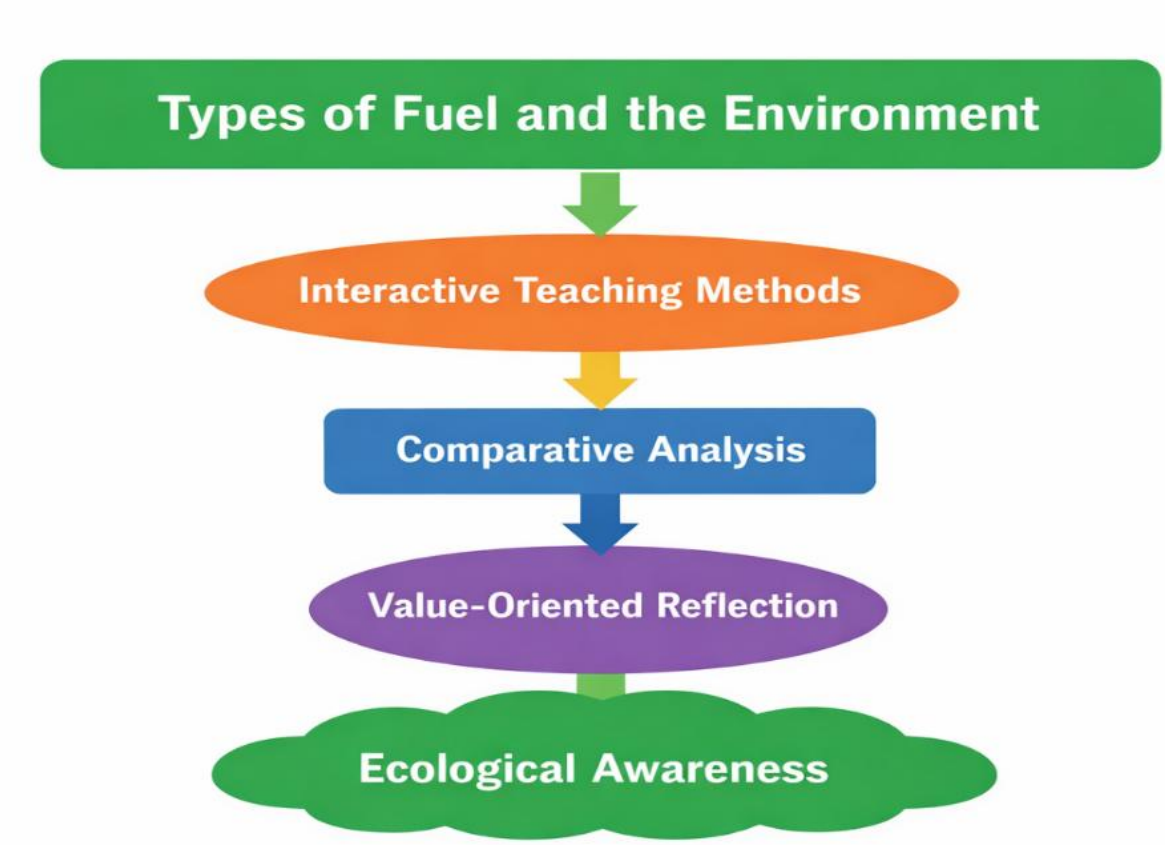


Figure 1. Model for Developing Ecological Awareness in Teaching the Topic "Types of Fuel and the Environment"

The figure presents a step-by-step model for developing ecological awareness while teaching the topic "Types of Fuel and the Environment." According to the model, the instructional process begins with the use of interactive teaching methods, which increase students' engagement and active participation. This is followed by comparative analysis, through which learners examine the characteristics of different fuel types and evaluate their effects on the environment. At the next stage, value-oriented reflection is encouraged, helping students develop environmental responsibility, sensitivity toward nature, and awareness of sustainable development. Thus, the figure demonstrates that teaching this topic is not limited to the transmission of theoretical knowledge, but also contributes to the formation of ecological awareness and responsible attitudes in students.

Methodological Foundations of Teaching

The formation of ecological awareness in this topic requires a well-grounded methodological approach. Several foundations are especially important.

1. Interdisciplinary Integration

The topic naturally integrates chemistry with biology, geography, physics, and environmental science. Chemistry explains the composition of fuels and the reactions of combustion. Biology and health education help students understand how polluted air affects living organisms and human health. Geography provides insight into natural resources, energy distribution, and regional environmental problems. Physics contributes to the understanding of energy efficiency and heat release. This interdisciplinary character enriches the lesson and prevents ecological content from appearing artificial. Students understand that environmental issues cannot be solved from the perspective of one subject alone. For example, when discussing vehicle fuel emissions, the teacher may connect chemical equations with air quality, urban health problems, and energy policy. Such integration broadens students' outlook and deepens their awareness.

2. Problem-Based Learning

Problem-based learning is particularly effective for this topic because ecological issues are inherently problem-oriented. The lesson may begin with a real-life situation: Why is air pollution greater in large cities? Why do some countries reduce coal use? Why is incomplete combustion dangerous in homes? Why are electric and hydrogen-based transport technologies gaining attention? A problematic situation stimulates curiosity and makes learning purposeful. Students are not passive recipients of information; they become investigators trying to explain a real phenomenon. Through this approach, ecological awareness develops as a result of intellectual engagement rather than moral instruction alone.

3. Contextual and Life-Oriented Teaching

The environmental meaning of the topic becomes clearer when it is linked to students' daily experiences. They see fuels in domestic heating, cooking, transport, power generation, and industrial production. A lesson based on familiar examples helps students realize that environmental chemistry is not distant or abstract. For instance, the teacher may invite students to compare natural gas used in households with gasoline used in cars, or firewood used in rural areas with coal used in industry. Such comparisons create a bridge between school knowledge and social reality. They also help students understand that fuel consumption patterns vary according to economic, geographical, and technological conditions.

Experimental and Demonstration Activities

Practical work is essential in chemistry teaching, and this topic provides many opportunities for safe demonstrations and model experiments. Students may observe the differences between complete and incomplete combustion, compare soot formation, examine flame characteristics, or analyze the conditions influencing combustion efficiency. Experimental observation makes ecological concepts concrete. For example, when students see soot deposition during incomplete combustion, they understand more clearly why some fuels are associated with indoor pollution and respiratory hazards. When they observe cleaner combustion under better oxygen supply, they see that environmental protection is linked with both chemical conditions and technological control [3, p110,5, p.4019].

Comparative Analysis and Critical Thinking

A major methodological principle in teaching this topic is comparison. Students should not study each fuel in isolation. Instead, they should compare fuels according to origin, chemical composition, energy output, accessibility, economic value, and environmental effect. This develops analytical thinking and balanced judgment. Below is a table that can be incorporated directly into the article or used during instruction.

Table 1.

Comparative Characteristics of Fuel Types and Their Environmental Impact

Fuel type	Main source/origin	Key chemical feature	Environmental concerns	Possible pedagogical focus
Coal	Fossil fuel	High carbon content	High CO_2 emissions, sulfur compounds, soot, ash	Air pollution, acid rain, industrial emissions
Oil and petroleum products	Fossil fuel	Complex hydrocarbon mixtures	CO_2 emissions, toxic exhaust gases, oil-related pollution	Transport emissions, fuel processing, combustion efficiency
Natural gas	Fossil fuel	Mainly methane	Lower soot and sulfur emissions, but still releases CO_2	Cleaner combustion, household fuel use, relative environmental advantages
Biomass	Organic renewable material	Carbon-based biological matter	Smoke, particulate matter, variable efficiency depending on technology	Renewable sources, rural fuel use, sustainability debates
Biofuels	Renewable biological feedstock	Organic compounds derived from plants or waste	Lower dependence on fossil fuels, but may raise land-use concerns	Alternative energy, environmental trade-offs
Hydrogen	Secondary energy carrier	Produces water in ideal use conditions	Production pathway may still involve environmental cost	Clean energy technologies, future transport solutions

This kind of comparison helps students understand that no fuel is entirely free from environmental consequences. At the same time, it allows them to evaluate why some fuels may be considered more acceptable under certain technological and ecological conditions.

Value-Oriented Reflection

Ecological awareness includes not only knowledge but also ethical reflection. Students should be encouraged to discuss human responsibility toward nature, rational resource use, and the need for sustainable energy choices. Such discussion should arise from scientific content rather than abstract moral instruction. For example, after studying emissions from different fuels, students may reflect on how communities can reduce environmental harm without compromising energy security. They may also consider their own habits related to energy saving, transportation, and resource use. In this way, chemistry education contributes to the development of responsible citizenship [10, p. 3554,2, p.345,9, p.115].

Suggested Instructional Model

A methodologically sound lesson on "Types of Fuel and the Environment" may be organized in several stages. At the motivational stage, the teacher introduces an environmental situation such as urban smog, acid rain, or increasing carbon emissions. Students are asked to suggest possible causes. This activates prior knowledge and creates an immediate need for learning. At the exploration stage, students classify fuels, study their composition and properties, and analyze the products of combustion. Demonstration or model experiments may be used to strengthen understanding. At the analytical stage, students compare fuels according to ecological criteria, discuss pollutant formation, and evaluate the relation between fuel choice and environmental quality.

At the reflection stage, they formulate conclusions, participate in a short debate, prepare a mini-poster, or respond in writing to a question such as: "Which fuel strategy is more environmentally responsible for the future?" The table below systematizes these instructional stages and their pedagogical significance.

Table 2.

Instructional Stages for Teaching the Topic "Types of Fuel and the Environment"

Lesson stage	Teacher activity	Student activity	Main pedagogical purpose
Motivation	Presents a real environmental problem related to fuel use	Expresses initial ideas and hypotheses	Activates prior knowledge and creates interest
Exploration	Introduces fuel types, composition, and combustion processes	Classifies fuels, studies reactions, observes examples	Builds scientific understanding
Experiment/Demonstration	Organizes safe observation of combustion conditions or model experiments	Observes, records, compares results	Makes ecological concepts concrete
Comparative analysis	Guides students to compare fuels by emissions and environmental effect	Analyzes data, completes comparison charts, discusses findings	Develops critical and analytical thinking
Reflection and discussion	Poses value-oriented and future-focused questions	Draws conclusions, evaluates alternatives, reflects on responsibility	Forms ecological awareness and responsible attitudes

Expected Pedagogical Outcomes

If this topic is taught on sound methodological foundations, several important outcomes may be achieved. First, students develop a more meaningful understanding of combustion and fuel chemistry. Second, they learn to interpret environmental problems scientifically rather than emotionally or superficially. Third, they improve their comparative, critical, and reflective thinking skills. Fourth, they form a more conscious attitude toward natural resources and environmental protection. Finally, they begin to see chemistry as a socially relevant science with direct importance for sustainable development. These outcomes are especially valuable in the modern educational context, where learners must be prepared not only for examinations but also for participation in a world shaped by energy choices, technological change, and ecological responsibility.

Conclusion

The topic "Types of Fuel and the Environment" has broad didactic potential for developing ecological awareness in school chemistry. Its educational value lies in the close connection between chemical knowledge and real environmental challenges. Effective teaching of this topic requires more than the presentation of classifications and reaction equations. It demands interdisciplinary integration, problem-based instruction, contextual learning, practical observation, comparative analysis, and reflective discussion.

When organized on these foundations, the study of fuels becomes a productive way of linking chemistry education with environmental education. It helps students understand the consequences of energy use, evaluate different fuel options critically, and develop more responsible ecological attitudes. For this reason, the topic should be regarded as one of the most effective areas for integrating scientific literacy with ecological consciousness in chemistry teaching.

References

1. Day, E. L., Petritis, S. J., McFall-Boegeman, H., Starkie, J., Zhang, M., & Cooper, M. M. (2024). A framework for the integration of green and sustainable chemistry into the undergraduate curriculum: Greening our practice with scientific and engineering practices. Journal of Chemical Education, 101(5), 1847–1857. doi:10. 1021/acs.jchemed.3c00737

2. Eilks, I., & Linkwitz, M. (2022). Greening the chemistry curriculum as a contribution to education for sustainable development: When and how to start? Current Opinion in Green and Sustainable Chemistry, 37, 100662. doi:10.1016/j. cogsc.2022.100662

3. International Energy Agency. (2025). CO2 emissions. In Global Energy Review 2025. IEA.

4. Li, B., & Eilks, I. (2021). A systematic review of the green and sustainable chemistry education research literature in mainland China. Sustainable Chemistry and Pharmacy, 21, 100446. doi:10.1016/ j.scp.2021.100446

5. López-Fernández, M. D. M., Cano-Iglesias, M. J., & Franco-Mariscal, A. J. (2025). Chemistry inquiry conducted by secondary school students into material degradation in the context of sustainability. RSC Sustainability, 3(9), 3997–4019. doi:10.1039/D5SU00176E

6. MacKellar, J. J., Constable, D. J. C., Kirchhoff, M. M., Hutchison, J. E., & Beckman, E. (2020). Toward a green and sustainable chemistry education road map. Journal of Chemical Education, 97(8), 2104–2113. doi:10.1021/ acs.jchemed.0c0028

7. Pashayeva, A. A., & Hasanova, S. M. Advantages of Using Interactive Teaching Methods in Chemistry Education. Proceedings of the Ahi Evran International Scientific Research Congress, Kırşehir Ahi Evran University, December 1–2, 2021, pp. 112–119.

8. Pashayeva, A. A., & Mirzayeva, J. N. The Didactic Tasks of Lessons in the Systematization of Knowledge and Skills in Chemistry Teaching. Proceedings of the XXIV International Scientific Symposium "Multidisciplinary Research in the Modern World," dedicated to the 85th anniversary of Farman Karimzade, Tbilisi, Georgia, March 26, 2022, pp. 66–68. ISBN: 978-605-71427-4-0.

9. Pashayeva, A. A., Mammadova, K. M., & Naghiyev, K. J. Application of Innovative Approaches in Laboratory Work to Develop Students' Logical-Critical Thinking and Research Skills. Modern Approaches and Innovative Methods in Chemistry Teaching Ankara, 2025, pp. 115–123.

10. Rahmawati, Y., Taylor, E., Taylor, P. C., Ridwan, A., & Mardiah, A. (2022). Students' engagement in education as sustainability: Implementing an ethical dilemma-STEAM teaching model in chemistry learning. Sustainability, 14(6), 3554. doi:10.3390/su14063554

11. Reynders, M., Pilcher, L. A., & Potgieter, M. (2023). Teaching and assessing systems thinking in first-year chemistry. Journal of Chemical Education, 100(3), 1357–1365. doi:10. 1021/acs.jchemed.2c00891

12. Sunday, E. S., Samuel, H. S., Rickson, N. H., Musa, J., & Etim, E. E. (2026). Impact of green chemistry education on students' learning and environmental awareness in chemistry. Discover Education, 5, 44. doi:10.1007/s44217-025-01056-7

13. Widyantoro, C., Han, J. Y., Ong, J. S. H., Goh, K. H., & Fung, F. M. (2025). Teaching sustainability through green chemistry: An experiential learning approach. Journal of Chemical Education, 102(7), 2743–2754. doi: 10.1021/acs.jchemed.4c01476

PHILOLOGICAL SCIENCES

ТОПОНИМИЧЕСКИЕ КОМПОНЕНТЫ В БОТАНИЧЕСКОЙ И ЗООЛОГИЧЕСКОЙ ТЕРМИНОЛОГИИ В РУССКОМ ЯЗЫКЕ

Аскерова З.А.
Бакинский государственный университет,
Магистрант кафедры русского языкознания

TOPONYMIC COMPONENTS IN BOTANICAL AND ZOOLOGICAL TERMINOLOGY IN THE RUSSIAN LANGUAGE

Asgarova Z.
Baku State University,
Master's Student of the Department of Russian Linguistics
DOI: 10.5281/zenodo.19327262

АННОТАЦИЯ

В статье систематизируются и анализируются топонимические компоненты в ботанической и зоологической терминологии в русском языке; прослеживается развитие и закрепление этих элементов в русском языке, анализируются их лингвистические особенности, функционирование и способы интеграции топонимов в биологическую и зоологическую терминологию русского языка, выявляются и описываются наиболее продуктивные модели словообразования, используемые при формировании подобных названий. Систематизация и анализ материала проводится по тематическим разрядам с учетом географического объекта (кратоним, астионим, гидроним и административный хороним). Примеры систематизируются и рассматриваются в двух соответствующих теме параграфах: 1) Ботаническая терминология; 2) Зоологическая терминология.

ABSTRACT

The article systematizes and analyzes toponymic components in botanical and zoological terminology in the Russian language; it traces the development and consolidation of these elements in the Russian language, analyzes their linguistic features,the functioning and methods of integrating toponyms into the biological and zoological terminology of the Russian language,identifies and describes the most productive word-formation models used in the creation of such names.The systematization and analysis of the material is carried out by thematic categories, taking into account the geographical object (cratonym, astionym, hydronym, and administrative horonym)..Examples are systematized and examined in two relevant sections: 1) Botanical Terminology; 2) Zoological Terminology.

Ключевые слова: топонимы, топонимические компоненты, русский язык, ботанические термины, зоологические термины, тематические разряды, продуктивные модели, структурно-семантические особенности, прилагательное.

Keywords: toponyms, toponymic components, the Russian language, botanical terms, zoological terms, thematic categories, productive models, structural and semantic features, adjectives.

Ботаническая и зоологическая терминология на протяжении длительного времени являются объектом пристального внимания лингвистов. Особый интерес, на наш взгляд, представляют топонимы, вошедшие в состав ботанической и зоологической терминологии. Изучение структуры и семантики таких терминов позволяет определить и разъяснить механизмы закрепления географических наименований в русском языке и их интеграцию в научную терминологию, одновременно указывая на места распространения организмов (видов) флоры и фауны и их характерные признаки. Следует отметить, что географические наименования позволяют раскрыть историческое прошлое народов, очертить границы прежнего распространения языков и проследить их генезис. Таким образом, можно прийти к выводу, что ботанические и зоологические термины, содержащие топонимические компоненты, выполняют бинарную функцию: они не только обозначают места обитания организмов, но и служат инструментом для их классификации и определения по родовой и видовой принадлежности.

Известно, что истоки ботанической терминологии уходят в глубь веков. В формировании русской ботанической лексики основную роль сыграла народная речь. XVIII век стал переломным моментом в развитии ботаники, так как запустил процесс формирования собственной научной терминологии. Этот процесс заключался в устранении полисемии и создании единого языка, который обогащался как русскими, так и заимствованными терминами. Ранние ботанические термины отличались использованием семантического словообразования, что являлось их отличительной чертой[10].

Цель исследования – изучение и систематизация топонимических компонентов в ботанической и зоологической терминологии в русском языке. В рамках настоящего исследования планируется проследить развитие и закрепление этих элементов в русском языке. Направленность исследования

предопределила постановку и решение следующих задач:

- Определить лингвистические особенности топонимов в названиях представителей флоры и фауны;

- проанализировать функционирование и способы интеграции топонимов в биологическую и зоологическую терминологию русского языка;

- выявить наиболее продуктивные модели словообразования, используемые при формировании подобных названий;

Научная новизна заключается в том, что в настоящей статье впервые систематизируются и анализируются ботанические и зоологические термины с топонимическими компонентами в русском языке.

Отметим, что ботанические и зоологические термины исследовались в различных аспектах (лингвокультурологическом, этимологическом, лексико-семантическом, литературным и др) [1,12,13,15,16,17,19]. В настоящей же статье впервые рассматриваются ботанические и зоологические термины, компонентами которых являются топонимические дериваты.

Поскольку в рамках одной статьи охватить все термины исследуемого разряда невозможно, мы ограничимся рассмотрением лишь наиболее интересных и оригинальных, на наш взгляд, примеров. Систематизация и анализ материала будут осуществляться по тематическим разрядам с учетом географического объекта (кратоним, астионим, гидроним и административный хороним).

Топонимы, являясь именами собственными, обозначают географические объекты. В языке их основная функция - идентификация, то есть указание на конкретный географический объект, но в терминологии они могут менять своё назначение. В ономастике этот процесс называется деонимизацией (апеллятивацией) - превращение онима в апеллятив, при котором слово теряет свой собственно-именной статус и становится частью общего словаря. Если топоним становится частью названия растения или животного, уточняя его вид, то происходит деонимизация. В этом случае слово утрачивает статус собственного имени и входит в ряды нарицательных названий. В данном случае топоним утрачивает самостоятельность как собственное имя и превращается в классификационный признак. Он интегрируется в атрибутивный компонент, чаще всего в относительное прилагательное, связывая номинацию с определенной территорией - ареалом, регионом, зоной распространения или историко-географической областью. Наиболее ярко это прослеживается в русской ботанической и зоологической терминологии, где топоним часто служит основой для образования прилагательных, например: *амурский, байкальский, кавказский* и т.д. В этих случаях географическое имя перестает быть самостоятельным названием места и функционирует как часть определения, выполняя роль классифицирующего признака.

Отметим сразу, что при анализе ботанических и зоологических терминов с топонимическими компонентами важно учитывать их словообразовательную структуру и морфологические особенности.

В ботанической и зоологической терминологии наблюдается две основные структурные модели названий: **однословные и двусловные.**

Проведённый анализ нами словарно-энциклопедических источников (в частности, Большой энциклопедический словарь, толковые словари и специализированные издания по зоологии, включая энциклопедии животных) показывает, что в русской ботанической и зоологической терминологии чаще всего наблюдаются двусловные наименования. Одновременно следует подчеркнуть: хотя двусловные конструкции в целом доминируют, в зоологической терминологии имеется большее количество однословных единиц по сравнению с ботанической терминологией. Такие **двусловные** конструкции обычно строятся по модели «**прилагательное + существительное»**, в которой прилагательное, производное от топонима, выполняет, *атрибутивную* функцию, существительное же указывает на вид/род растений или животных, например такие словосочетания, как: *альпийская роза, испанский дрок, польский гриб, испанский можжевельник, исландский мох* (в ботанике) *и сиамская кошка, итальянская пчела, австрийский меринос, байкальская нерпа, тибетский мастиф, китайская чайка, гималайский медведь (*в зоологии*).* Особо следует отметить следующий интересный пример синонимии: *суданская мальва - китайская роза - гибискус,* а *испанский дрок – метельник.*

Отдельный продуктивный класс составляют сложные прилагательные с компонентами направления: *северо-, юго-, западно-, восточно-* и их комбинациями (юго-восточно-, северо-западно- и др.) например: *североамериканский дикобраз, юго-восточноазиатская кошка, западносибирская лайка, западно-гималайская пихта.*

В русской орфографической норме принципиально различаются:

- написание в составе официальных географических названий (возможна дефисность и прописные);
- употребление в качестве нарицательного определения, где в научной речи часто закрепляется слитность и строчная буква, поскольку слово функционирует как обычное прилагательное.

В русских зоологических и ботанических наименованиях с топонимическим компонентом встречаются два устойчивых порядка слов: ***препозиция определения и постпозиция определения***. При препозиции прилагательное стоит перед опорным существительным (*шотландская кошка,каспийский лосось, индийский слон*) а при постпозиции - после него (*сосна сибирская, опунция индийская и т.д)*. Такая перестановка компонентов рассматривается как инверсия и является не случайностью, а вариантом оформления одного и того же наименования.

Выбор порядка обычно зависит от **жанра и коммуникативной задачи.** В нейтральном изложении и научно-популярной речи предпочтительна

модель «признак + предмет», поскольку она привычна для современного русского синтаксиса. В справочной и классификационной подаче нередко используется обратный порядок: сначала называется объект, затем даётся уточнение, что удобно для систематизации и перечислений. Дополнительным фактором служит влияние научной традиции, связанной с латинской биномиальной номенклатурой, где сначала идёт родовое обозначение, а затем - уточняющее; при переводе и терминологической адаптации это может поддерживать постпозицию н определения в русских названиях. Такой порядок значительно облегчает классификацию и систематизацию, что важно для перечней, описаний и рубрикации. Таким образом, вариативность препозиции и постпозиции в значительной мере определяется жанровой установкой и задачей представления терминологической информации.

Выше было указано, что однословные наименования в целом представлены ограниченно; тем не менее их анализ выявил ряд показательных примеров, значимых для описания словарной фиксации и вариативности: *бергамот, араукария, тайвания* (в ботанической терминологии) *и чихуахуа, акита, балинез, питерболд, саванна* (в зоологической терминологии).

Примеры систематизируются и рассматриваются нами в двух соответствующих теме параграфах:

1) Ботаническая терминология

1.1 **от названия кратонима** (название государства или страны): **Ливанский кедр** – хвойное дерево, ставшее символом государственности и духовности. Исторически ареал растения был сосредоточен в горах Ливана, где кедр почитался с древних времен как ценный строительный материал для храмов и судов. Изображение этого дерева сегодня украшает государственный флаг Ливана[6]; **Индийский лотос** – многолетнее водное растение, глубоко укоренившееся в культуре и религии полуострова Индостан. Свое название вид получил благодаря широкому распространению в водоемах Индии, где цветок считается священным[3].

1.2 от названия астионима (название города): **Дамасская роза** – декоративный сорт роз, известный своим исключительным ароматом. Считается, что в Европу растение было завезено из столицы Сирии – Дамаска – участниками крестовых походов в XIII веке[7]; **Флорентийский ирис** – многолетнее растение, ставшее символом итальянского города Флоренция еще в XII веке. Название связано с массовым произрастанием этого вида в окрестностях города. Экстракт корня флорентийского ириса исторически использовался в парфюмерии и медицине, прославив тосканский регион как центр производства ценных эфирных масел[8].

1.3 от названия гидронима (от названия водного пространства): **Байкальский шлемник** – многолетнее травянистое растение, эндемик Прибайкалья и Забайкалья. Первые научные описания данного вида связаны с его произрастанием на побережье озера Байкал. Растение широко известно в восточной медицине благодаря своим уникальным свойствам, которые сформировались в специфических климатических условиях крупнейшего пресноводного озера планеты[7].

1.4 От названия административного хоронима: **Сахалинская гречиха** (также *рейнутрия сахалинская*) – крупное травянистое растение, первоначальный ареал которого охватывает остров Сахалин. Название указывает на административно-территориальную единицу, где растение было впервые обнаружено и описано как массовый вид[4].

2)Зоологическая терминология

2.1 **от названия кратонима** (от названия страны или государства): **Итальянская левретка** (малая итальянская борзая) – порода собак, чей облик сформировался еще в Древнем Риме. Несмотря на египетские корни, название закрепилось за породой благодаря ее исключительной популярности в Италии эпохи Возрождения, где она стала символом аристократии и украшала полотна великих итальянских мастеров [2,3]; **Азербайджанский горный меринос** – высокопродуктивная порода овец, выведенная в середине XX века на территории Азербайджана. «Государственное» название породы связано с селекционной работой, проводившейся в хозяйствах республики (в частности, в Гедабекском районе) для создания животного, приспособленного к специфическим условиям высокогорных пастбищ Кавказа[4].

2.2 **От названия астионима** (от названия города): **Ангорская кошка** (также *турецкая ангора*) – древняя порода домашних кошек, происходящая из города Ангора. Первые упоминания о длинношерстных кошках из этого региона относятся к XVI веку, когда они начали вывозиться в Европу в качестве ценных подарков от османских султанов [2,3]; **Пекинес** – священная порода собак китайских императоров, выведенная в древнем Пекине более 2000 лет назад. В Европе порода стала известна лишь в 1860 году после захвата Пекина британскими войсками[12].

2.3 **от названия гидронима** (от названия водного пространства): **Нильский крокодил** - крупнейшая из трех видов рептилий, обитающих в Африке. Его название неразрывно связано с рекой Нил, где на протяжении тысячелетий этот хищник был объектом религиозного поклонения и страха. Впервые был научно описан как вид, доминирующий в бассейне этой великой водной артерии [2,3]; **Каспийский тюлень** (*каспийская нерпа)* – единственный вид ластоногих в фауне Каспийского моря. Считается, что предки этого тюленя проникли сюда из северных морей в ледниковый период [4,20]; **Эрдельтерьер** – порода собак, название которой происходит от долины реки Эйр (Aire) в графстве Йоркшир (Великобритания). Слово dale означает долина, таким образом, термин буквально переводится как «терьер из долины реки Эйр», где порода была выведена в середине XIX века для охоты на речных выдр[3,9].

2.4 **От названия административного хоронима**: **Далматин** – порода собак, получившая свое название от исторической области Далмация (тер-

ритория современной Хорватии). Первые достоверные изображения пятнистых собак, похожих на современных представителей породы, были найдены в церковных летописях этого региона, датированных началом XVIII века, что и закрепило за ними географическое имя. Итак, топокомпоненты в составе зоологических и ботанических наименований в русском языке представляют большой географический и лингвокультурологический интерес[3,12].

Литература

1. Бабакулов И. Т., Мажидова Х. И. К изучению ботанических терминов и их словообразования // Ученый XXI века. – 2022. – № 9 (90).URL: https://cyberleninka.ru/article/n/k-izucheniyu-botanicheskih-terminov-i-ih-slovoobrazovaniya (дата обращения: 02.03.2026)

2. Биологический энциклопедический словарь / под ред. М. С. Гилярова; авт. кол.: А. А. Бабаев, Г. Г. Винберг, Г. А. Заварзин и др. – 2-е изд., испр. – М.: Сов. Энциклопедия, 1986. – URL: https://rus-bio-dict.slovaronline.com (дата обращения: 02.03.2026).

3. Большая российская энциклопедия: [электронный ресурс] / науч.-ред. совет: пред. Ю. С. Осипов и др. – М.: Большая Российская энциклопедия, 2004–2026. – URL: https://bigenc.ru (дата обращения: 02.03.2026).

4. Большая советская энциклопедия: в 30 т. / гл. ред. А. М. Прохоров. – 3-е изд. – М.: Советская энциклопедия, 1969—1978. – URL: https://www.booksite.ru/fulltext/1/001/008/130/index.htm (дата обращения: 02.03.2026).

5. Большой энциклопедический словарь / гл. ред. А. М. Прохоров. – 2-е изд., перераб. и доп. – М.: Большая Российская энциклопедия; СПб.: Норинт, 2000. – 1456 с. – URL: https://rus-big-enc-dict.slovaronline.com (дата обращения: 02.03.2026).

6. Брокгауз Ф. А., Ефрон И. А. Энциклопедический словарь. — С.-Пб.: Брокгауз-Ефрон, 1890—1907. — URL: https://rus-brokgauz-efron.slovaronline.com (дата обращения: 02.03.2026).

7. Гончарова Т. А. Энциклопедия лекарственных растений: (лечение травами): в 2 т. / Т. А. Гончарова. — М.: Изд. Дом МСП, 1997. — Т. 1. — URL: https://www.cnshb.ru/AKDiL/0019/default.shtm (дата обращения: 02.03.2026).

8. Епишкин Н. И. Исторический словарь галлицизмов русского языка. — М.: ЭТС, 2010. — 5140 с. — URL: https://rus-gallicismes-dict.slovaronline.com (дата обращения: 02.03.2026).

9. Животные в доме: энциклопедия / под ред. В. Г. Гребцовой, М. Г. Таршиса, Г. И. Фоменко. — М.: Большая Российская энциклопедия, 1994. — URL: https://bio.niv.ru/doc/dictionary/house-animals/index.htm (дата обращения: 02.03.2026).

10. Жигунова Е. А. Формирование ботанической терминологии в языке русской науки XVIII – первой четверти XIX в.: автореф. дис.... канд. филол. наук. — Череповец, 2006. — 22 с. — URL: https://www.dissercat.com/content/formirovanie-botanicheskoi-terminologii-v-yazyke-russkoi-nauki-xviii-pervoi-chetverti-xix-ve (дата обращения: 02.03.2026).

11. Круковер В. И. Полная энциклопедия пород собак. — М.: Вече, 2003. — 336 с.

12. Меркулова В. А. Очерки по русской народной номенклатуре растений. Травянистые растения / отв. ред. О. Н. Трубачев; Акад. наук СССР, Ин-т рус. яз. – М.: Наука, 1967. – 259 с. – URL: https://www.booksite.ru/fulltext/rusles/merkocherki/text.pdf (дата обращения: 02.03.2026).

13. Прищепа М. М. ТОПОНИМЫ В ЛИТЕРАТУРНОМ ПРОСТРАНСТВЕ СБОРНИКА РАССКАЗОВ О ШЕРЛОКЕ ХОЛМСЕ АРТУРА КОНАН ДОЙЛА // На пути к гражданскому обществу. – 2022. – № 2 (46). – URL: https://cyberleninka.ru/article/n/toponimy-v-literaturnom-prostranstve-sbornika-rasskazov-o-sherloke-holmse-artura-konan-doyla (дата обращения: 02.03.2026).

14. Российское общество историков-архивистов (РОИА). К 100-летию государственной архивной службы России: официальный сайт. — М., 2018. — URL: https://rosih.ru/index.php?page=141 (дата обращения: 02.03.2026).

15. Саркисова А. Ю. Топонимы в литературном пространстве сборника рассказов о Шерлоке Холмсе Артура Конан Дойла // Балтийский гуманитарный журнал. – 2018. – Т. 7, № 2 (23). – С. 143–146. – URL: https://cyberleninka.ru/article/n/toponimy-v-literaturnom-prostranstve-sbornika-rasskazov-o-sherloke-holmse-artura-konan-doyla (дата обращения: 02.03.2026).

16. Сердюкова Е. В. ВИДЫ ТОПООСНОВ В РУССКИХ ДОНСКИХ ГОВОРАХ: СЕМАНТИЧЕСКИЕ ОСОБЕННОСТИ // Научная мысль Кавказа. – 2023. – № 3 (115). – URL: https://cyberleninka.ru/article/n/vidy-topoosnov-v-russkih-donskih-govorah-semanticheskie-osobennosti (дата обращения: 02.03.2026).

17. Умарова М. Х. ЛИНГВИСТИЧЕСКАЯ КЛАССИФИКАЦИЯ ТОПОНИМИИ СУРХАНДАРЬИНСКОЙ ОБЛАСТИ // Экономика и социум. – 2023. – № 6-1 (109). – URL: https://cyberleninka.ru/article/n/lingvisticheskaya-klassifikatsiya-toponimii-surhandarinskoy-oblasti (дата обращения: 02.03.2026).

18. Ушаков Д. Н. Толковый словарь русского языка: в 4 т. — М.: Гос. изд-во иностр. и нац. словарей, 1935—1940. — URL: https://ushakovdictionary.ru/view_search.php (дата обращения: 02.03.2026).

19. Фаткуллина Ф. Г. ТОПОНИМЫ КАК КОМПОНЕНТ ЯЗЫКОВОЙ КАРТИНЫ МИРА // Современные проблемы науки и образования. – 2015. – № 1-1. – URL: https://science-education.ru/ru/article/view?id=18126 (дата обращения: 02.03.2026).

20. Энциклопедический словарь / [под ред. А. Б. Мещерякова]. — М. : АСТ : Астрель, 2009. — 1584 с. — URL: https://niv.ru/doc/dictionary/encyclopedic/index.htm (дата обращения: 02.03.2026).

A COMPARATIVE ANALYSIS OF ACADEMIC WRITING CONVENTIONS IN ENGLISH AND RUSSIAN

Tursunovna G.,
Candidate of Philosophical Sciences, Professor
Karaganda University of Kazpotrebsoyuz, Karaganda, Kazakhstan
Myrzakhanova A.
1st-year Master's Student
Karaganda University of Kazpotrebsoyuz, Karaganda, Kazakhstan
DOI: 10.5281/zenodo.19327273

ABSTRACT

This article examines the main conventions of academic writing in English and Russian from a contrastive rhetorical perspective. The study examines differences in text organization, paragraph development, authorial stance, metadiscourse, hedging, and syntactic structure. The analysis is based on a qualitative review of research on contrastive rhetoric, academic discourse, Russian scholarly style, and international publication standards. The findings show that English academic writing usually follows a more linear and explicitly structured pattern, with strong reader guidance, clear signaling of argument stages, and careful limitation of claims. Russian academic writing, in contrast, has traditionally allowed broader conceptual framing, denser exposition, and less overt rhetorical signposting. At the same time, the study shows that these differences are becoming less rigid under the influence of international publishing requirements. The article concludes that effective academic writing instruction for bilingual scholars should be based not only on language proficiency, but also on a clear understanding of rhetorical expectations in both traditions.

Keywords: academic writing, contrastive rhetoric, academic discourse, English, Russian, metadiscourse, hedging, scholarly communication, IMRAD.

Introduction. Academic writing is not merely a neutral medium for transmitting information. It is a historically shaped discourse practice through which knowledge is organized, legitimized, and presented to a disciplinary community. One of the foundational contributions to the study of rhetorical variation across languages was made by Robert B. Kaplan, who argued that written discourse patterns vary across linguistic and cultural traditions and that these differences affect the organization of academic prose [1].

Later scholarship refined this early contrastive model and showed that differences in academic writing cannot be reduced to a simple opposition between national styles. Michael Clyne demonstrated that English-language academic prose tends to privilege linear progression and explicit textual organization, whereas Germanic and Slavic traditions may tolerate more digression, denser conceptual exposition, and a less overtly signposted argumentative path [2]. Anna Duszak, examining intellectual style in academic discourse, likewise showed that scholarly writing reflects broader epistemic and cultural preferences, including differing expectations about abstraction, interpersonal distance, and the distribution of authorial authority in the text [3].

Research on English academic discourse has repeatedly emphasized the importance of reader orientation. Ken Hyland has shown that academic prose is structured not only through propositional content but also through metadiscourse, that is, linguistic resources by which writers guide readers, anticipate possible objections, signal stance, and negotiate disciplinary credibility [4]. This observation is especially important in English-medium scholarly communication, where clarity of progression, explicit framing of claims, and careful management of certainty and limitation are central to publication success. In relation to Slavic academic traditions, Tatyana Yakhontova has argued that differences between Anglo-American and Eastern European scholarly writing are visible in textual arrangement, authorial self-presentation, and the rhetorical handling of evidence, although such differences are also shaped by genre and disciplinary variation [5]. Contemporary work on Russian academic writing confirms that Russian scholarly discourse is not static. Rather, it is currently situated in a zone of transition in which inherited conventions of Russian scientific prose increasingly interact with international English-dominant publication norms [6], [7].

This issue has become especially significant in the context of global academic publishing. Reporting standards developed by organizations such as the American Psychological Association, together with editorial policies of international journals, have strengthened expectations regarding article structure, transparency of method, concise abstracts, and clearly staged presentation of results [8], [9]. As a result, many researchers working in Russian academic environments are now required to move between two partly overlapping but not identical rhetorical systems.

Against this background, the present article aims to identify the principal similarities and differences between academic writing conventions in English and Russian and to formulate an analytically grounded comparison that may be useful for bilingual scholarly writing instruction and publication practice.

Literature Review. The scholarly discussion of academic writing conventions across languages has evolved from broad cultural descriptions toward more nuanced, genre-sensitive, and discourse-oriented analysis. Kaplan's early work established the premise that discourse organization is culturally patterned [1], but later researchers complicated this view by showing that rhetorical variation depends not only on language and

culture, but also on discipline, genre, institutional norms, and publication ecology. Clyne's analysis of academic texts foregrounded the role of linearity and textual progression [2], whereas Duszak emphasized intellectual style and the ways in which discourse communities shape acceptable forms of scholarly reasoning [3]. Hyland moved the discussion further by demonstrating that academic writing is deeply interpersonal: stance, engagement, hedging, and textual self-management are not ornamental features but constitutive elements of scholarly argumentation [4]. Yakhontova's comparative studies showed that authors educated in Slavic academic traditions often enter English-medium publishing with different assumptions about explicitness, paragraphing, and rhetorical sequencing [5]. More recent work on Russian scholarly communication has shown that the pressure of international publication standards is transforming Russian academic writing, especially in abstracts, journal articles, and university writing instruction, although local norms continue to influence textual form and argumentative rhythm [6], [7]. Taken together, these studies suggest that English and Russian academic writing should not be treated as mutually isolated systems. Rather, they should be understood as historically distinct yet increasingly interacting traditions whose differences become most visible in structure, authorial positioning, and reader guidance.

Materials and Methods

Research Design

The study adopts a qualitative research design aimed at identifying systematic similarities and differences between English and Russian academic writing conventions within the framework of contrastive rhetoric and academic discourse analysis.

Research Methods

Several complementary research methods were applied in the analysis:

• Comparative analysis

Used to identify structural and rhetorical differences between English and Russian academic writing conventions.

• Contrastive rhetorical analysis

Applied to examine how discourse organization, argument development, and reader orientation differ across the two linguistic traditions.

• Discourse analysis

Used to analyze the linguistic and rhetorical features of academic texts, including paragraph organization, textual cohesion, and argumentative sequencing.

• Metadiscourse analysis

Applied to examine the use of metadiscursive markers that guide readers through the text and signal the author's stance.

Analytical Framework

Analytical Procedure

The research process included three stages. First, relevant literature on academic writing conventions was systematically reviewed. Second, recurrent rhetorical features described in previous studies were categorized according to the analytical framework. Third, these features were compared across the English and Russian traditions in order to identify stable patterns of difference and areas of convergence influenced by international publication practices.

Results. The comparison shows that English academic writing is generally characterized by stronger linear progression, more explicit signaling of argumentative stages, and a higher degree of reader-oriented framing. In English-medium scholarly prose, it is common for the research problem, gap, method, and contribution to be clearly marked early in the text. This convention reduces interpretive burden for the reader and creates a visible architecture of argument. Russian academic writing, by contrast, has traditionally allowed a slower movement toward the central claim. The framing may be broader, the conceptual background more extended, and the transition to the core argument less abruptly signposted.

Table 1.

Major differences between English and Russian academic writing conventions

Parameter	English academic writing	Russian academic writing
Argument progression	Usually linear and explicitly staged	Often more gradual and conceptually layered
Reader guidance	Strong signposting and transition markers	Less overt signposting in traditional prose
Authorial stance	Often moderated through hedging	May appear more categorical or implicitly positioned
Paragraph design	Topic-driven, tightly structured	Can be longer and more syntactically expanded
Publication orientation	Strongly shaped by journal norms and international standards	Historically shaped by national scholarly style, now increasingly hybrid

These differences do not mean that one system is more rigorous than the other. Rather, they indicate that rigor is textualized differently. In English, rigor is frequently associated with transparency, staging, and explicit limitation of claims. In Russian scholarly prose, rigor has often been associated with conceptual fullness, terminological density, and the demonstration of theoretical command.

A second important distinction concerns metadiscourse. English academic texts often guide the reader through phrases that clarify textual movement, indicate evidential caution, or define the scope of claims. Hyland's work on metadiscourse and hedging shows that such markers are integral to disciplinary persuasion, not merely stylistic preference [4]. Russian academic writing also employs stance and textual organization markers, but in many traditional texts they are

less frequent or less foregrounded, which may create an impression of greater textual compactness and lower interactional visibility.

Table 2.

Metadiscursive tendencies in the two traditions

Feature	English	Russian
Explicit transitions	Frequent	Less frequent in traditional academic prose
Hedging devices	Highly developed and publication-sensitive	Present, but often distributed differently
Reader engagement	More visible	Often more implicit
Self-positioning	Strategically managed	Sometimes less explicitly individualized

A third difference concerns syntactic organization. Research by Douglas Biber and Bethany Gray has shown that modern academic English tends toward dense nominal structures, compression of information, and highly elaborated noun phrases rather than clause-heavy exposition [10]. Russian academic prose can also be dense, but this density often takes a somewhat different form, involving long sentence architecture, embedded qualifications, and extended logical unfolding. Thus, both traditions may appear intellectually dense, yet they achieve that density through partly different grammatical means.

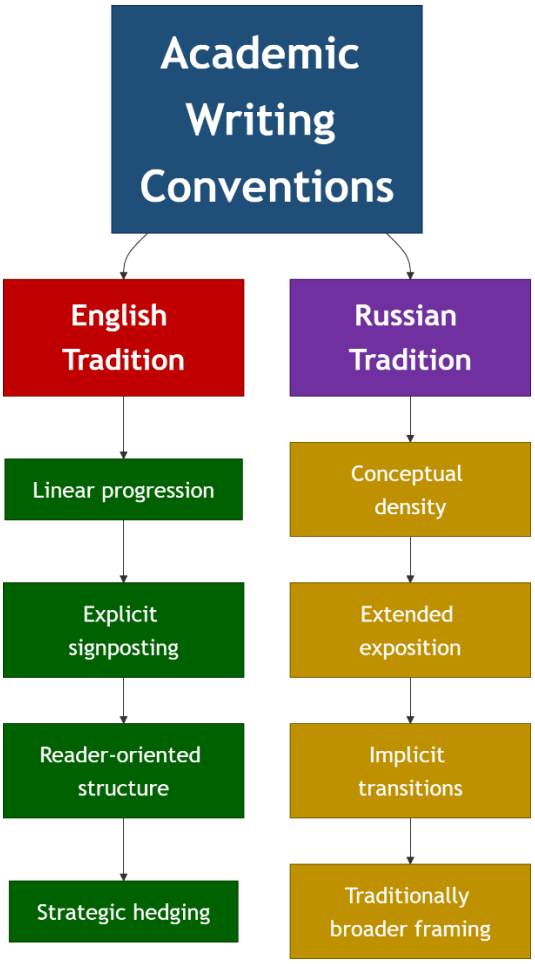


Figure 1. Comparative model of rhetorical emphasis

The evidence also indicates that the gap between the two traditions is narrowing. Studies of contemporary Russian academic communication show increasing adaptation to English-dominant publication norms, especially in article abstracts, structured introductions, and the presentation of empirical results [6], [7]. This is especially visible in journals that require bilingual metadata, internationally recognizable abstracts, and standardized article architecture.

Discussion. The comparison demonstrates that academic writing conventions in English and Russian differ not only at the level of language form but also at the level of rhetorical expectation. This circumstance serves as a basis for understanding why many bilingual scholars experience difficulty even when they possess strong subject knowledge. The problem often lies not in grammar alone, but in a mismatch between discourse habits and the expectations of the target academic community.

On this basis, it can be concluded that English academic writing places greater value on anticipatory organization. The reader is not expected to infer the trajectory of the argument with minimal guidance. Instead, the writer is expected to signal the path of

reasoning, delimit claims, and make the contribution legible early. Russian academic writing, especially in its more traditional forms, has often permitted greater interpretive participation from the reader and a more gradual disclosure of the argumentative center. Consequently, a text that appears intellectually rich in one tradition may appear insufficiently explicit in the other.

This divergence has practical consequences for publication, graduate writing instruction, and academic translation. When Russian-speaking researchers prepare manuscripts for English-medium journals, difficulties often arise in the introduction, abstract, and discussion sections. Claims may be formulated too broadly, the research gap may be insufficiently specified, or the contribution may appear too late in the textual sequence. Conversely, when English rhetorical norms are transferred mechanically into Russian, the result may sound overly segmented or stylistically alien to readers formed within Russian scholarly conventions.

A productive response to this situation is not to oppose the two traditions in hierarchical terms, but to develop contrastive academic literacy. Such literacy requires explicit training in how claims are framed, how caution is encoded, how paragraphs are organized, and how writer-reader relations are managed in each discourse system. This creates a precondition for more effective bilingual publication practice.

Conclusion. The analysis shows that English and Russian academic writing conventions are shaped by different rhetorical histories, different assumptions about reader guidance, and different preferences in the distribution of structure, stance, and density. English academic prose tends toward explicit progression, rhetorical transparency, and carefully staged argumentation. Russian academic prose has traditionally favored broader conceptual framing, greater syntactic extension, and a less overtly signposted movement toward the main claim. At the same time, the influence of international publication standards is bringing the two traditions into closer contact, especially in empirical journal writing.

This creates an important methodological implication for higher education. Academic writing instruction should be built not on abstract prescriptions alone, but on a comparative understanding of discourse conventions. For bilingual scholars, the decisive competence is not merely language proficiency, but the ability to shift between rhetorical expectations without losing conceptual precision. From this perspective, the comparison of English and Russian academic writing is not a peripheral stylistic issue. It is a central condition of participation in contemporary global scholarship.

References

1. Kaplan, R. B. Cultural thought patterns in intercultural education / R. B. Kaplan // Language Learning. - 1966. - Vol. 16, No. 1-2. - P. 1-20. https://onlinelibrary.wiley.com/doi/10.1111/j.1467-1770.1966.tb00804.x

2. Clyne, M. Cultural differences in the organization of academic texts / M. Clyne // Journal of Pragmatics. - 1987. - Vol. 11, No. 2. - P. 211-247. https://www.sciencedirect.com/science/article/pii/0378216687901962

3. Duszak, A. Academic discourse and intellectual styles / A. Duszak // Journal of Pragmatics. - 1994. - Vol. 21, No. 3. - P. 291-313. https://www.sciencedirect.com/science/article/pii/0378216694900035

4. Hyland, K. Disciplinary interactions: Metadiscourse in L2 postgraduate writing / K. Hyland // Journal of Second Language Writing. - 2004. - Vol. 13, No. 2. - P. 133-151. https://www.sciencedirect.com/science/article/pii/S1060374304000025

5. Yakhontova, T. Cultural and disciplinary variation in academic discourse: The issue of influencing factors / T. Yakhontova // Journal of English for Academic Purposes. - 2006. - Vol. 5, No. 2. - P. 153-167. https://www.sciencedirect.com/science/article/abs/pii/S1475158506000038

6. Kolesnikova, N. I. Russian scientific style vs academic writing: problem points of interaction / N. I. Kolesnikova // Terra Linguistica. - 2022. - Vol. 13, No. 1. - P. 42-57. https://human.spbstu.ru/en/article/2022.47.4/

7. Smirnova, N. V. English and/or Russian medium publications? A case study exploring academic research writing in contemporary Russian academia / N. V. Smirnova, T. Lillis, A. K. Hultgren // Journal of English for Academic Purposes. - 2021. - Vol. 54. - Art. 101015. URL: https://oro.open.ac.uk/76381/

8. American Psychological Association. Journal Article Reporting Standards [Electronic resource]. - URL: https://apastyle.apa.org/jars

9. Springer Nature. Scientific Reports - Submission guidelines [Electronic resource]. https://www.nature.com/srep/author-instructions/submission-guidelines

10. Biber, D. Nominalizing the verb phrase in academic science writing / D. Biber, B. Gray // The Verb Phrase in English / ed. by B. Aarts, J. Close, G. Leech, S. Wallis. - Cambridge: Cambridge University Press, 2013. - Chapter 5. - DOI: 10.1017/CBO9781316694580.010.

11. Boginskaya, O. A. Functional categories of hedges: A diachronic study of Russian research article abstracts / O. A. Boginskaya // Russian Journal of Linguistics. - 2022. - Vol. 26, No. 3. - P. 645-667. https://journals.rudn.ru/linguistics/article/view/32089

12. Boginskaya, O. Evaluative Stancetaking in English-Medium Academic Prose: A Study of Research Article Abstracts by Russian and Chinese L2 Writers / O. Boginskaya // Journal of Language and Education. - 2024. - Vol. 10, No. 3. - P. 40-52. https://jle.hse.ru/article/view/16080

PHYSICS AND MATHEMATICS

METHOD FOR DETERMINING THE FLUID TENSION COEFFICIENT USING THE LOGARITHMIC APPROACH

Starodub Y.,
Doctor of Sciences (Physics and Mathematics), Professor,
Hushchak R.
PhD, Associate Professor
DOI: 10.5281/zenodo.19327294

ABSTRACT

This article is about studying the leakage of volumes from physical objects like voluminous bodies carrying necessary liquid products. The idea is to investigate the wetting coefficient of a liquid flowing through an assumed circular opening, so that one can investigate the situation by changing the material of the opening, and the physical nature of the substance that can flow through the opening. The work is proposed as an improvement and the development of the methodology for studying the coefficient of fluid tension in laboratory work conducted by the University of Life Safety, concerned with the fluid tension coefficient and fire safety of the endangered objects. The fluid tension coefficient is modelled, and the accuracy of the calculation is assessed using a logarithmic approach.

Keywords: study, fluid tension, logarithmic approach.

Fundamentals of the Investigation. The research in this paper is devoted to the determination of surface tension using capillary tubes under the influence of the inclination of these tubes and the size of the holes, which are associated with the flow of liquids, the surface tension coefficient of which is determined. Previous studies (see [1, 2]) do not take into account the possibility of determining the tension coefficient using a single tube, as well as the inclination of the tubes when fluid flows through them. However, in practice, there are often cases where circular holes or those close to them are of different diameters and are inclined differently, which requires additional insight into the situation with the influence of the tension coefficient of the flowing liquids. This work is devoted to considering such a situation, when various materials holes can be used in objects that are equivalent to the capillaries, with similar coefficient of fluid tension for the fire service safety.

Model of experiment. The study of internal molecular pressure in capillaries and small holes in a liquid due to surface tension is described by Laplace's formula [3]. According to Laplace the pressure difference $\triangle p$ on both sides of the capillary surface with two mutually perpendicular radii of circles corresponding to two circles R_1 i R_2 appears in the form

$$\triangle p = \sigma\left(\frac{1}{R_1} + \frac{1}{R_2}\right),$$

with the coefficient of surface tension σ.

For the purpose of practical evaluation of the coefficient of fluid tension and typical openings which are in practice we can assume that the radius of the capillary opening is close to circular then the radii of the mutually perpendicular R_1 and R_2 can be equal (or can be considered) equal. In this case, the changes in the liquid pressure in the vertical direction along the meniscus with radius R can be represented taking into account the tension in the form $\triangle p = \frac{2\sigma}{R}$. If we assume that the force of gravity of the liquid restrained by tension on the meniscus can be represented in the form $\triangle p = \rho g h$, where, respectively, ρ is the density, g the acceleration of gravity h is the height of the restrained fluid due to the tension coefficient, then we can calculate the tension coefficient by the formula

$$\sigma = 0.5R\rho g h. \quad (1)$$

In the latter formula, if we take the density ρ of the liquid wetting the capillary and the acceleration of gravity g as known quantities, it is necessary to measure the height h of the column of liquid wetting the capillary and take into account the radius of the drop that can be thrown or dropped by the capillary of the liquid wetting it. We take the shape of a spherical drop with a radius R which is equal to half the diameter d of the capillary.

The volume of one drop is calculated using the formula

$$V = \frac{\pi d^3}{6}. \quad 2)$$

In this case, the volume of the liquid column h in the capillary is equal to the volume of N drops:

$$N\frac{\pi d^3}{6} = \frac{\pi d^2}{4}h.$$

From the last equality we can find the height of the liquid column in the capillary$h$, use formula (1) to determine the coefficient of fluid tension and formula (2) to determine the volume of the drop and we will obtain the value of the determination of the fluid surface tension coefficient (1) in the form

$$\sigma = \frac{\rho V g}{\pi d N}, \quad (3)$$

where ρ is the acceleration of gravity, ρ is the density of the liquid under study, V – the volume of liquid in the wetted capillary, d is the diameter of the capillary, and N is the number of drops in the volume of the capillary of the liquid under study in the experiment.

Surface tension coefficient and errors. To find relative error of the surface tension coefficient of the liquid under study, we will use the logarithmic method. For this we logarithmize the fluid tension coefficient (3) [4]:

$$ln\,\sigma = ln\,\rho + ln\,V + ln\,g - ln\,\pi - ln\,d - ln\,N.$$

Differentiating the resulting expression we will have

$$\frac{D\sigma}{\sigma} = \frac{D\rho}{\rho} + \frac{DV}{V} + \frac{Dg}{g} - \frac{D\pi}{\pi} - \frac{Dd}{d} - \frac{DN}{N}.$$

Taking into account that errors can only accumulate and grow, in the last expression we change the minus sign to a plus sign. We will have

$$\frac{D\sigma}{\sigma} \leq \frac{D\rho}{\rho} + \frac{DV}{V} + \frac{Dg}{g} + \frac{D\pi}{\pi} + \frac{Dd}{d} + \frac{DN}{N}.$$

Differentials from constant quantities such as the acceleration of gravity g and the number π are equal to zero, therefore, replacing all differentials with experimental errors, we will have

$$\varepsilon = \frac{D\sigma}{\sigma} \leq \frac{D\rho}{\rho} + \frac{DV}{V} + \frac{Dd}{d} + \frac{DN}{N}. \quad (4)$$

The obtained expression makes it possible to find the absolute error of the experiment

$$\Delta\sigma = \varepsilon\sigma.$$

Calculations. We studied the surface tension coefficient for tap water. The experimental data are as follows: capillary diameter $d = 0.445 \cdot 10^{-3}$ m, number of drops N =212, density of water ρ =1000 kg/m^3, volume of water $V = 2\ 10^6$ m^3, acceleration due to gravity g =9.81 m/sec^2. Surface tension coefficient according formula (3) for the tap water obtained

$$\sigma = \frac{\rho V g}{\pi d N} = 0.066 N/m. \quad (5)$$

The error of the experiment would be around 10% according to formula (4), where all differentials were determined with an accuracy of 1/10%.

The surface tension coefficient for water at 20°C has a value by authors Halliday & Resnick of the book Fundamentals of physics_[5] $\sigma = 0.0728 N/m$. Tap water containing impurities partially weakens molecular interaction and tension, in particular the coefficient of surface tension, and it decreases. Tap water containing impurities partially weakens molecular interaction and tension, in particular the coefficient of surface tension, and it decreases. Therefore, the result obtained as a result of experiment (5) coincides with the data published in particular in work [5]. For tap water in the temperature range 18-22°C the surface tension is given approximately by [5] $\sigma \simeq (0.065 \div 0.068) N/m$ which coincides with the result obtained in the expression (5).

The results obtained were used by one of the authors in modelling problems [6,7].

Conclusions

Based on the results obtained in the experiment, we can conclude that The deviation of the surface tension coefficient values $\sigma = 0.066 N/m$ from those for clean water $\sigma = 0.0728 N/m$ for water pipe water is close to those values given in reference books [5,8]. Determining the composition of impurities when finding the surface tension coefficient makes it possible to roughly estimate the purity (of type salt of calcium, magnesium, chlorine organic substances, sometimes detergent substances in small quantities) in water and the contribution of impurities that pollute it. It can be seen from the formula (4) that increasing the number of drop measurements when determining liquid tension, relative non-increase the density and volume, and the diameter of the capillaries makes it possible to reduce the error. Estimating the surface tension coefficient makes it possible to estimate the liquid tension of substances, especially in practice.

References

1. Галчин Б.М., Дутчак Я.Й., Френчко В.С. Молекулярна фізика. Лабораторний практикум: Навч. Посібник. – Львів: Світ, 1990. – 240 с.: іл.

2. Физический практикум. Механика и молекулярная физика. Под.ред.В.И. Ивероновой Изд-во «Наука»,1967.

3. Воловик П.М. Фізика для університетів. Повний курс в одному томі. Київ: Перун. – 2005. – 864 с.

4. Зачек І.Р. Лабораторний практикум з фізики Ч.1.: Механіка та молекулярна фізика: практикум/ І.Р.Зачек та інші. – Львів: Вид-во Львівської політехніки. 2024. – 160 с.

5. Halliday, David Fundamentals of physics / David Halliday, Robert Resnick, Jearl Walker.—9th ed., 1330 p.

6. Nikolaevich, K.V., Starodub, Y., Havrys, A. Computer Modeling in the Application to Geothermal Engineering. – Advances in Civil Engineering, 2021.

7. Starodub Y., Mykhalichko B., Lavrenyuk H., Kozionova O., Polcik H., Kuplovskyi B. Enviromental geo-informational monitoring system for the civil and fire safety services of Ukraine. Visnyk of Taras Shevchenko National University of Kyiv. Geology, 2024, 2(105), pp. 104–110.

8. Landau, Lev D.; Lifshitz, Evgeny M. (1987). Fluid Mechanics. T. 6 (вид. 2nd). Butterworth-Heinemann.

TRANSPORT PARTICLES

Polyanskaya A.,
PhD in Physics,
Moscow State University (MSU)
Parfentyeva N.,
PhD in Physics, Professor,
Parfentyev N.
PhD in Physics, Associate Professor
Moscow State University of Engineering (MGSU)
DOI: 10.5281/zenodo.19327315

ABSTRACT

Einstein's formula for the mass of a moving body assumes the existence of four types of bodies: two types with real values of mass at a speed less than the speed of light and two with different signs and an imaginary value of mass (the speed is greater than the speed of light). Interaction of temporary states of bodies allows us to consider the force of inertia as a type of interaction. At the same time, an additional real force of the temporary interaction of particles with imaginary mass was revealed. Within the framework of the new concept, it follows that at any point in the trajectory of a moving body, Newton's third law is observed. The transfer of energy at the speed of light is carried out by photons formed by two particles moving at superluminal speeds - tachyons. The transmission of impulse momentum at a speed close to the speed of light is carried out by neutrinos formed by two particles of real mass, but with different signs. The huge number of neutrinos in the world means that the amount of positive and negative energy modulo is equal to each other.

Keywords: particle models, types of interactions, transfer of physical parameters.

Introduction

More than a century ago, Einstein proposed a formula for calculating the mass of a moving body. Since then, only bodies moving at a speed less than the speed of light and a positive value of mass are considered to actually exist (Left part of Figure 1). In the time that has passed since Einstein's discovery, the indisputability of the idea he proposed has become inevitable. However, the mathematical form of this equation inevitably leads to the possibility of the existence of four kinds of bodies (right side of Figure 1).

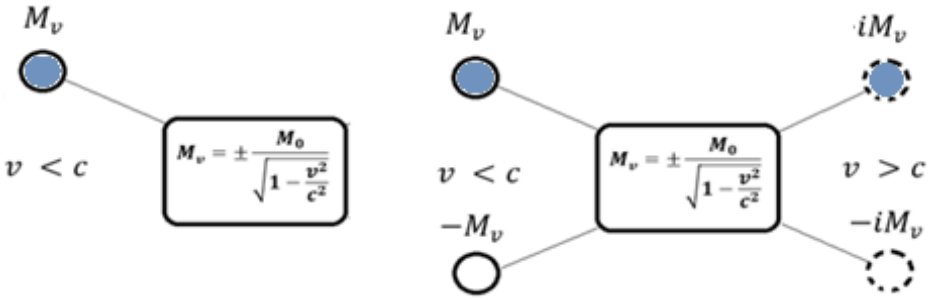


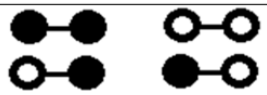
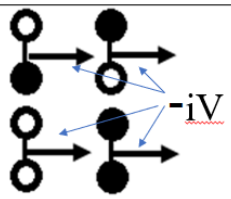
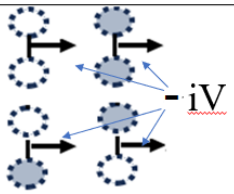
Figure 1: Types of Einstein solids.

The concept of the interaction of physical bodies (with positive mass) was developed by Newton – gravitation, on the basis of which a picture of the planetary scale is built. At the same time, Newton established the universal principle of equality of action and reaction on the basis of the communicative form of the gravitational equation. Recognizing this principle of Newton, let us determine the sign of the force of interaction for different types of physical bodies.

To solve the problem, it is convenient to expand the function Sign(x), used in programming, into the field of imaginary numbers. We believe that Sign (±ix) =± i. At the same time, let us take into account that velocity ($V=\frac{\Delta x}{ic\Delta t}=-i\frac{\Delta x}{c\Delta t}$) is an imaginary quantity, since it is the ratio of the increment of the spatial coordinate to the increment of the time coordinate (imaginary value). Table 1 shows the data for calculating the sign of the forces of interaction of Einstein's bodies according to the formula Sign(a*b)=Sign(a)*Sign(b)

Table 1

Signs of the forces of gravitational and electromagnetic interaction.

Type of interaction	View	Result
Static gravity		(1*1) ∪ (-1*-1)=1 (-1*1) ∪ (1*-1)=-1
Gravity of moving bodies		(i*-i) ∪ (-i*i)=1 (i*i) ∪ (-i*-i)=-1
The power of the pendant		(i*-i) ∪ (-i*i)=1 (i*i) ∪ (-i*-i)=-1
Ampere Power		(-1*-1) ∪ (1*1)=1 (-1*1) ∪ (1*-1)=-1

1 – attraction of bodies to each other, -1 – repulsion.

The table calculates the exact signs of the Coulomb and Ampere forces, assuming that the charges are physical bodies moving at a speed greater than the speed of light. The rationale for this assumption is given below. Modern ideas about the photon and neutrino give paradoxical results [1..16]

Stable photon and neutrino models

In this part, ideas are developed that make it possible to consider the types of bodies obeying Einstein's formula as real.

The main provisions relate to the role of the time coordinate

Equal time coordinate rights

1. Time intervals are calculated as imaginary values.
2. Physical objects on the time axis interact with each other
3. As in space, the interaction encompasses all states of the body on the time axis, including the future state
4. The interaction manifests itself in the absence of symmetry of temporal states—with ideal symmetry (uniform rectilinear motion of bodies according to Newton's law 1), the total interaction of temporal states is equal to zero.

Expanding the arsenal of forces

The analysis of the interaction of temporal states of physical bodies [17..21] eliminates the logical contradiction in determining the force of inertia in Newton's second law: $F = ma$

This formula is replaced by a commutative form of interaction between temporary state indicators - T

$$F_{21} = F_{12} = \frac{E}{ic\Delta t_{12}} = \frac{T_1 T_2}{ic\Delta t_{12}} \quad [T]=\sqrt{Дж} \qquad (1)$$

The indicator is constructed as a radical of the Einstein fraction of the bodies

$$T = \sqrt{\frac{mc^2\,\Delta x}{\sqrt{(\Delta x)^2+(ic\Delta t)^2}}} \qquad (2)$$

The resultant force is the vector sum of interactions

$$\overrightarrow{F_r} = \frac{\overrightarrow{T_{fut}T_{pr}}}{ict} + \frac{\overrightarrow{T_{pas}T_{pr}}}{ict} \qquad (3)$$

As a result, the canonical formulas for the force of inertia have been obtained, and the postulate of the equivalence of inertial and gravitational mass, which has been tried to prove theoretically and empirically for several centuries, becomes superfluous.

In particular, when the body moves in a circle, we get

$$|F_{rep}| = -\frac{m_0 v_-{}^2}{R\sqrt{1-(\frac{v_-}{c})^2}} \qquad (4)$$

m_0— mass of protoparticle,

v_-— the speed of the physical body.

Application of the proposed method for calculating force using indicators that include the increment of time in the numerator, $T = \sqrt{\frac{mc^2\,ic\Delta t}{\sqrt{(\Delta x)^2+(ic\Delta t)^2}}}$ leads to a force formula of the second kind. This force takes on a real value when a physical body moves at a speed greater than the speed of light – a tachyon. Thus, it is established that tachyon: 1 is an Einstein particle, 2 with its asymmetric motion along the time coordinate, a real force arises. Details of this process are given below

In particular, when such a body moves in a circle

$$|F_{attr}| = +\frac{mcv}{iR\sqrt{1-(\frac{v}{c})^2}} = +\frac{m_0 c v_+}{R\sqrt{(\frac{v_+}{c})^2-1}} \qquad (5)$$

v_+— the speed of a physical body exceeding the speed of light.

Pay attention to the automatically generated signs of the interaction forces: repulsion at the speed of a

body at a speed of less than the speed of light and attraction when the body moves at a speed greater than the speed of light.

In general, the formula for indicator T gives eight complex values of the indicator for four values of the root expression (two real and two imaginary). Figure 2 shows the complex values of the indicator for this set.

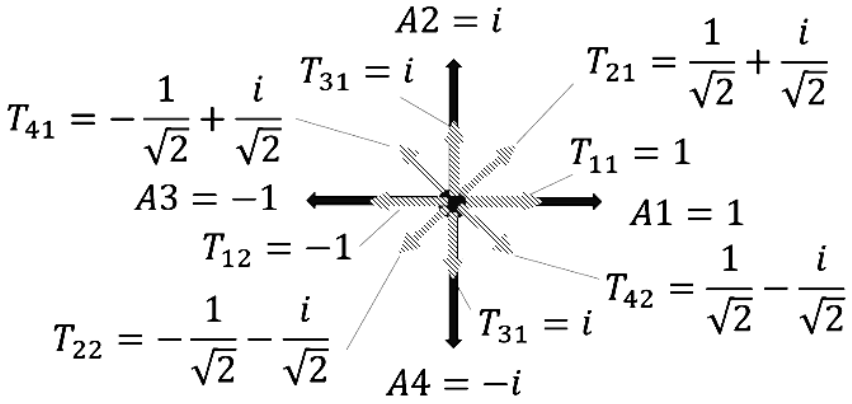


Figure 2. Complex multipliers of the T indicator.

In this paper, we will limit ourselves only to commutative formulas of forces obtained with the same multipliers of indicators.

Consider the motion of a tachyon along a harmonic trajectory (Figure 2)

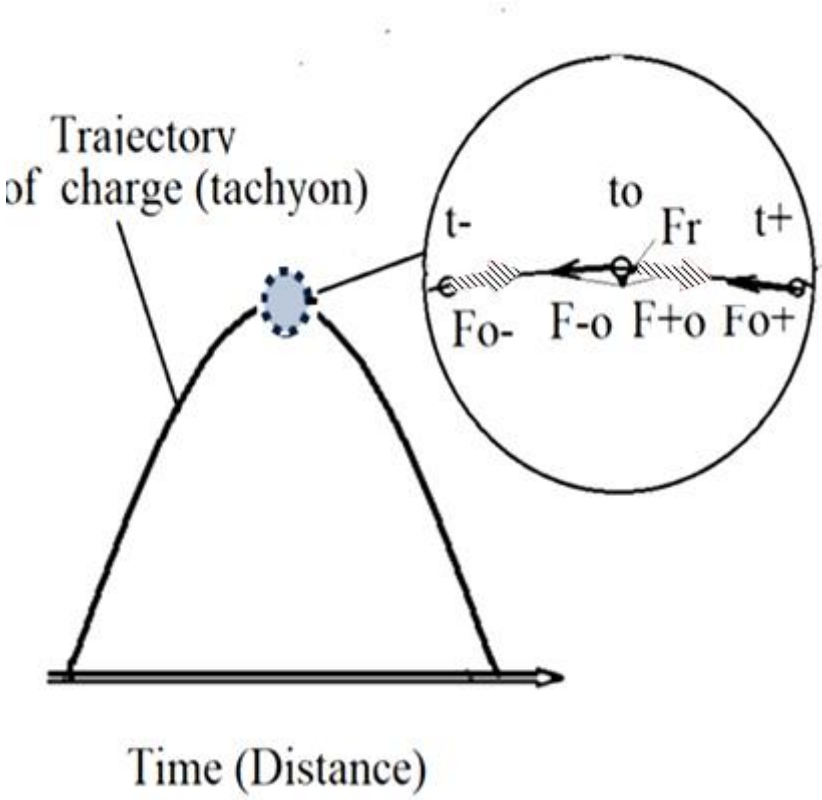


Figure 3 Motion of a tachyon along a harmonic trajectory.

Real forces at work

$\overrightarrow{F_{0-}}$ **Present to Past**

$\overrightarrow{F_{-0}}$ Past to Present ,

$\overrightarrow{F_{+0}}$ **Future to the present**,

$\overrightarrow{F_{0+}}$ Present for the future

$$\left|\overrightarrow{F_{0-}}\right|=\left|\overrightarrow{F_{-0}}\right|=\left|\overrightarrow{F_{+0}}\right|=\left|\overrightarrow{F_{+0}}\right| = F = \frac{m_0 v_+}{\Delta t\sqrt{(\frac{v_+}{c})^2-1}}, \quad (6)$$

The modulus of the total vector is

$$|\vec{F_r}| = 2F\Delta\alpha = \frac{2\pi\nu m_0 v_+}{\sqrt{(\frac{v_+}{c})^2 - 1}} \quad (7)$$

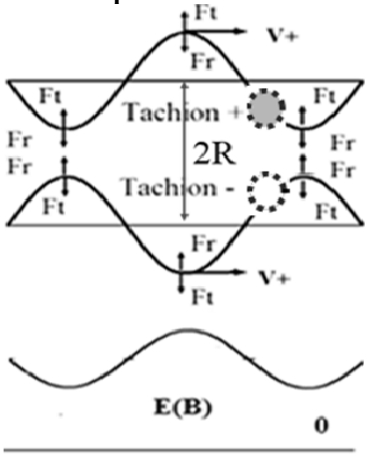
Under the assumption of a small mass of the proto-particle, the difference between the tachyon's velocity and the speed of light - $\Delta_+ = v_+ - c \ll c$.

Then

$$|\vec{F_r}| = \frac{2\pi\nu m_0 v_+}{\sqrt{\frac{2\Delta_+}{c}}} \quad (8)$$

Let us note that an increase in the tachyon's velocity leads to a decrease in its charge; for example, a quark with a charge of 1/3e moves faster than a quark with a charge of 2/3e.

Model of a photon in the form of two tachyons with different signs



Fr — the result of the forces of electromagnetic interaction,

Ft — the strength of the interaction of temporal states,

V+ — The speed is greater than the speed of light.

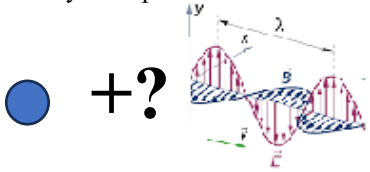
Figure.4 Photon Model

For aesthetic reasons, the figure uses one and a half periods of oscillation of the system.

Result

1. Charge is translated from a particle property into the main characteristic of a tachyon moving at a speed exceeding the speed of light.
2. Two moving different tachyons are attracted to each other at a short distance and repel each other at a relatively long distance.
3. The latent force balances the total strength of the electromagnetic interaction of the tachyons.
1. Photon carries energy

$$E_{ph} = 2FR = + \frac{4\pi\nu m_0 v_+}{\sqrt{(\frac{v_+}{c})^2 - 1}} R = h\nu \quad (9)$$

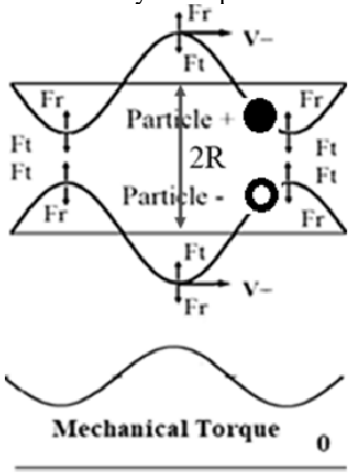
Photon dualism	Classic Introduction	Model
Composition	Mystical particle 	A system of two differently charged tachyons
Weight	Zero photon mass	No real mass, zero total imaginary mass
Energy	Proportional to frequency	Proportional to frequency
Motion in dielectric media	Speed reduction	Path length increases due to interaction Photon and Molecule Dipoles

The expansion of the arsenal of forces makes the possibility of the existence of Einstein particles with imaginary mass real.

The photon model explains the paradox of the presence of an electromagnetic wave produced by a particle with a zero charge value.

Neutrino model

The existence of neutrinos creates the paradox of the existence of a particle with a significant angular momentum with a very small particle mass.



The paradox is resolved by constructing a model of a particle in the form of two Einstein particles differing in the **sign of real mass**

Fr — Result of gravitational forces,

Ft — The Power of Interaction of Temporal States,

V- — the speed is less than the speed of light.

Figure 5 Neutrino model

Within the framework of the proposed model, the neutrino spin is equal to

$$h \approx 2\boldsymbol{v}\_R \frac{\boldsymbol{m_0}}{\sqrt{\mathbf{1}-(\frac{\boldsymbol{v}_-}{\boldsymbol{c}})^2}} \quad (10)$$

m_0 — mass of protoparticle,

v_-— the speed of the neutrino components, which is close to the speed of light,

2R — Mean Particle Spacing.

The force (interactions of time states) acting on the particles at the extremes of the harmonic trajectory is equal to

$$F_t = 2\pi \frac{\boldsymbol{m_0 v_-}}{\sqrt{\mathbf{1}-(\frac{\boldsymbol{v}_-}{\boldsymbol{c}})^2}} \nu \quad (11)$$

ν – Harmonic Frequency.

At the same time, we assume that the mass of the protoparticle is so small that the difference in velocity $\boldsymbol{\Delta}_- = \mathrm{c} - \boldsymbol{v}_- \ll \mathrm{c}$. Then

Then

$$F_t = 2\pi \frac{\boldsymbol{m_0 v_-}}{\sqrt{\frac{\boldsymbol{2\Delta_-}}{\boldsymbol{c}}}} \nu \quad (12)$$

Note that the coincidence of the formulas for the force (8) and (12), unlike tachyons, an increase in the velocity of neutrino particles will lead to an increase in their mass

Model properties

1. The neutrino model is made up of two Einstein particles of different real masses that move at a speed close to the speed of light

2. Particles repel each other at a short distance and are attracted at a relatively greater distance.

3. The force of interaction of time states balances the net force of gravity at any point in the trajectory.

4. Neutrinos carry torque because the moments of the particles add up

$$\boldsymbol{h} = \mathbf{2} \frac{\boldsymbol{m_0 v_-}}{\sqrt{\mathbf{1}-(\frac{\boldsymbol{v}_-}{\boldsymbol{c}})^2}} \boldsymbol{R} \quad (13)$$

The similarity of photon and neutrino models determines their properties, in particular, the general inverse dependence of the distance between particles on frequency.

Consequences of model structure

1. The model explains the conservation of momentum during neutron decay.

2. Neutrinos are able to transmit mechanical momentum during the translational motion of their elements.

Conclusions

1. The inclusion of the forces of interaction of temporal states in the arsenal of acting forces reveals the existence of all kinds of Einsteinian particles.

2. At any point in the trajectory of moving bodies, Newton's third law is observed.

3. The transfer of energy at the speed of light is carried out by photons formed by two tachyons

4. Momentum transfer is carried out by neutrinos formed by two particles of large mass, but with different signs.

5. The amount of positive and negative neutrino flux energy is equal to each other modulo.

References

1. Astronomers Accurately Measure the Mass of Neutrinos for the First Time. scitechdaily.com (10 февраля 2014). Дата обращения: 7 мая 2014. Архивировано 8 мая 2014 года.

2. Foley, James A. Mass of Neutrinos Accurately Calculated for First Time, Physicists Report. natureworldnews.com (10 февраля 2014). Дата обращения: 7 мая 2014. Архивировано 8 мая 2014 года.

3. Battye, Richard A.; Moss, Adam. Evidence for Massive Neutrinos from Cosmic Microwave Background and Lensing Observations (англ.) // Physical Review Letters: journal. — 2014. — Vol. 112, no. 5. — P. 051303. — doi:10.1103/PhysRevLett.112.051303. — Bibcode:2014PhRvL.112e1303B. — arXiv:1308.5870v2. — PMID 24580586.

4. Haxton W. C. The Solar Neutrino Problem (англ.) // Annual Review of Astronomy and Astrophysics[англ.]. — 1995. — Vol. 33. — P. 459—504. Архивировано 11 августа 2021 года.

5. Герштейн С. С., Куденко Ю. Г. Лауреаты Нобелевской премии 2015 года. По физике — А. Макдональд, Т. Каджита // Природа. — Наука,

2016. — № 1. — С. 59—64. Архивировано 5 августа 2020 года.

6. Пять загадок физики после бозона Хиггса. Масса нейтрино. Дата обращения: 13 августа 2014. Архивировано 14 августа 2014 года.

7. Куденко Ю. Г. Нейтрино - ключ к загадкам Вселенной? // Природа. — Наука, 2017. — № 6. — С. 3—11. Архивировано 4 августа 2018 года.

8. Serebrov A. P. et al. On the Possibility of Performing an Experiment in the Search for a Sterile Neutrino // Technical Physics Letters. — 2014. — Т. 40. — С. 456—459. — doi:10.1134/S106378501406011X.

9. Serebrov A., Fomin A., Samoilov R. The Experiment Neutrino-4 on the Search for Sterile Neutrino at SM-3 Reactor (англ.) // Moscow University Physics Bulletin. — 2022. — Vol. 77. — P. 401–406. — doi:10.3103/S0027134922020904.

10. Рудик Д. Эксперимент PROSPECT не нашел стерильных нейтрино. https://nplus1.ru/. N+1 (5 мая 2025). Дата обращения: 6 мая 2025. Архивировано 6 мая 2025 года.

11. Formaggio J. A., de Gouvêa A. L. C., Robertson R. G. H. Direct measurements of neutrino mass (англ.) // Physics Reports. — 2021. — Vol. 914. — P. 1–54. — doi:10.1016/j.physrep.2021.02.002. Архивировано 22 ноября 2021 года.

12. Астрономы получили самую точную оценку массы «частицы-призрака». РИА Новости (22 июня 2010). Дата обращения: 22 июня 2010. Архивировано 22 августа 2011 года.

13. Thomas S. A., Abdalla F. B., Lahav O. Upper Bound of 0.28 eV on Neutrino Masses from the Largest Photometric Redshift Survey (англ.) // Phys. Rev. Lett.. — 2010. — Vol. 105, iss. 3. — P. 031301. Архивировано 25 января 2024 года.

14. Нейтрино ограничили вдвое. ТАСС. Дата обращения: 13 апреля 2025. Архивировано 13 апреля 2025 года.

15. Ландау Л. Д. Об одной возможности для поляризационных свойств нейтрино // ЖЭТФ. — 1957. — Т. 32, № 2. — С. 407—408. Landau L. D. {{{заглавие}}} (англ.) // JETP. — 1957. — Vol. 5. — P. 337—338.

16. Salam A. On parity conservation and neutrino mass (англ.) // Nuovo Cim.. — 1957. — Vol. 5. — P. 299—301. — do

17. Parfentiev N.A. On the nature of the force of inertia. KiberLeninka, 2017. URL: https://cyberleninka.ru/article/n/o-prirode-sily-inertsii.

18. Parfentev Nikolay Andreevich, Parfenteva Natalia Andreevna. Force of Inertia as Sort of Interaction. Engineering Mathematics. Vol. 5, No. 2, 2021, pp. 22-24.

19. Parthentiev N. A., Partfenteva N. A. Connection of Newton’s formula for Kinetic Energy and Einstein Formyla, Sciences of Europe # 63, (2021) 47.

20. Parfentev N. A. Interpretation of the Results of the Real Wheeler’s Experience. Engineering Mathematics 2018; 2 (2): 86-88

21. Parfentyev N.A., Parfentyeva N.A., Schubert M. A model of a photon within the framework of a temporal interaction. In print.

POLITICAL SCIENCES

FROM FUNCTIONAL SPILLOVER TO STRATEGIC VISION: NEOFUNCTIONALIST DYNAMICS IN THE ORGANIZATION OF TURKIC STATES

Hasanov J.
The Academy of Public Administration Under the President of the Republic of Azerbaijan
https://orcid.org/0009-0002-3741-6918
DOI: 10.5281/zenodo.19327335

ABSTRACT

This article examines how neofunctionalist dynamics—especially the mechanism of functional spillover—help explain the gradual integration of the Organization of Turkic States (OTS). Drawing on a qualitative study of official declarations (including the Nakhchivan and İstanbul summits), the Turkic World Vision–2040 document, institutional reports (TURKSOY, Turkic Academy, TURKUNIB), and secondary literature, I trace how cooperation in one policy area produces pressure and opportunity for cooperation in others. The analysis finds two clear pathways of spillover in the Turkic case. First, people-to-people and cultural cooperation (language, heritage, cultural institutions) has catalyzed deeper collaboration in education and research—manifested in curriculum harmonization goals, student mobility initiatives, and the Orkhun Process. Second, expanding economic ties have generated complementary cooperation in transport, customs, energy and logistics, turning symbolic affinity into concrete political-economic projects. I argue that umbrella institutions of the OTS function as focal actors that translate soft convergence (shared identity and values) into institutionalized practices, thereby validating neofunctionalism as a useful framework outside the European experience. The paper concludes with policy implications: strengthening institutional capacity, prioritizing regulatory harmonization (education and trade), and sequencing projects to maximize positive spillovers. By combining process-tracing with content analysis, the study offers a measured, empirically grounded account of how a strategically framed Vision–2040 can convert cultural kinship into durable regional cooperation.

Keywords: Neofunctionalism; functional spillover; Organization of Turkic States (OTS); Turkic; World Vision–2040; regional integration; TURKSOY; education cooperation; economic integration.

INTRODUCTION

Following the dissolution of the Soviet Union in 1991, the Turkic republics emerged as independent states, inaugurating a new historical phase for the Turkic world. This period was characterized by intensified efforts to institutionalize regional cooperation, largely promoted by Türkiye. In this context, a range of organizations were established to support collaboration across cultural, academic, political, and economic domains, including the International Organization of Turkic Culture

(TURKSOY), the International Turkic Academy, the Parliamentary Assembly of Turkic-Speaking Countries (TÜRKPA), the Turkic Culture and Heritage Foundation, the Turkic Investment Fund, and the Organization of Turkic States (OTS). Collectively, these institutions constitute the core institutional architecture of cooperation within the Turkic world.

Among these bodies, the Organization of Turkic States occupies a particularly prominent position due to its comprehensive institutional framework and its function as an umbrella organization that coordinates political dialogue and cooperation among Turkic states (Kocaman, 2021). The strategic vision and institutional initiatives of the OTS exert both direct and indirect influence on other cooperation mechanisms within the Turkic world, shaping their priorities and trajectories. Accordingly, this study places primary emphasis on the Organization of Turkic States as the central coordinating institution and on the Turkic World Vision–2040 as its long-term strategic roadmap. Within this framework, cooperation initiatives in the Turkic world and the roles of related institutions are examined through the analytical lens of new institutionalism, which provides a suitable theoretical approach for assessing how the Vision–2040 document structures norms, rules, and patterns of cooperation among Turkic states.

Neofunctionalism and Functional Spillover in the Integration Process of the Organization of Turkic States

This thesis analyzes the integration process between Türkiye and the Turkic states by employing neofunctionalist theory, particularly the concept of functional spillover, as its principal analytical framework. Neofunctionalism posits that cooperation initiated in one policy area tends to generate pressures for collaboration in adjacent sectors, thereby fostering incremental and cumulative integration. Within the context of the Organization of Turkic States (OTS), evidence of functional spillover can be observed across multiple domains. Notably, cooperation in cultural affairs has facilitated and deepened collaboration in education and academic exchange. Institutions such as TURKSOY, the International Turkic Academy, and the Turkic Culture and Heritage Foundation operate across sectoral boundaries, contributing simultaneously to cultural preservation, educational coordination, and knowledge production. Their multidimensional activities demonstrate how sectorspecific initiatives evolve into broader integrative dynamics, reinforcing the relevance of the functional spillover mechanism. From this perspective, the activities of OTS-affiliated umbrella institutions constitute a tangible indicator of neofunctionalist processes at work.

In addition to socio-cultural dimensions, economic cooperation among OTS member states has also

generated spillover effects into related sectors, particularly transportation, energy, and connectivity. As economic interaction intensifies, the need for coordinated policies and infrastructure development in these complementary areas becomes more pronounced. Accordingly, this study contends that neofunctionalism provides a convincing theoretical framework for explaining the gradual and sectorally interconnected nature of integration within the Organization of Turkic States.

Political and cultural dimensions of cooperation were further articulated during the Eighth Summit of Turkic-Speaking States, where a range of shared positions and policy orientations were adopted. The Antalya Declaration emphasized the continuation of TÜRKSOY's activities in promoting cultural cooperation and a shared Turkic identity, supported Kazakhstan's candidacy for the presidency of the OSCE, and reaffirmed calls for a comprehensive settlement of the Cyprus issue. The summit also highlighted expanded collaboration within the Organization of Islamic Cooperation, endorsed the candidacies of Türkiye (2009–2010), Kazakhstan (2010–2011), and Kyrgyzstan (2012– 2013) for non-permanent membership in the United Nations Security Council, and encouraged a peaceful resolution of the Karabakh conflict in line with Azerbaijan's sovereignty and territorial integrity [Musabay Baki, Pelin 2022]

The Nakhchivan Summit of 2009 represents a critical turning point in the institutionalization of Turkic integration. This summit is widely regarded as a milestone for two principal reasons. First, it marked the formal establishment of the Cooperation Council of Turkic-Speaking States (Turkic Council) through the Nakhchivan Agreement, creating an intergovernmental organization that brought together Azerbaijan, Kazakhstan, Kyrgyzstan, and Türkiye. Second, the summit laid the groundwork for a more structured and enduring institutional framework, providing the Turkic states with a formal mechanism for coordination and collective action. As such, the Nakhchivan Summit significantly advanced the institutional foundations of Turkic cooperation and reinforced the longterm trajectory of regional integration.

On 16 September 2010, the Tenth Summit of the Heads of State of Turkic-Speaking Countries was convened in İstanbul, culminating in the adoption of the İstanbul Declaration. This summit is widely regarded as inaugurating a new phase in the process of Turkic integration. Deliberations primarily focused on shared perspectives regarding peace and security, the enhancement of economic cooperation, the functioning of the Secretariat of the Cooperation Council of Turkic-Speaking States (CCTS), the activities of the Council of Elders and the Academy of Turkic World Studies, as well as broader issues related to the institutional structuring of Turkic cooperation. The İstanbul Declaration, adopted at the conclusion of the summit, formally articulated these priorities and set out a common framework for future collaboration [Baranyi, Tamás P 2022].

Subsequently, the First Summit of the CCTS was held in Almaty on 21 October 2011, with a central agenda devoted to "Economic Cooperation among Turkic-Speaking Countries." The summit was attended by the Presidents of Kazakhstan, Azerbaijan, and Kyrgyzstan, alongside the Prime Minister of Türkiye. In addition to state leaders, key representatives of Turkic cooperation institutions participated, including Dyusen Kasseinov, Secretary General of TURKSOY, and Ramil Hasanov,

Secretary General of the Parliamentary Assembly of Turkic-Speaking Countries (TÜRKPA). Discussions at the Almaty Summit addressed the strengthening of cooperation at both regional and international levels and explored avenues for expanding collaboration in trade, economic affairs, cultural exchange, and humanitarian issues among member states.

Shaping the Future of the Turkic World: An Analysis of the Turkic World Vision–2040

The Turkic World Vision–2040 presents a comprehensive strategic framework that articulates both the long-term objectives and the future orientation of the Turkic world. A systematic examination of this document is therefore of critical importance for understanding the prospective trajectory of cooperation and integration among Turkic states. The Vision–2040 not only outlines policy priorities but also reflects a broader attempt to position the Turkic world within the evolving international system.

At the outset, the Turkic World Vision–2040 is clearly formulated in alignment with prevailing international norms and institutional principles. It makes explicit reference to the global order and to major international organizations—most notably the United Nations and the normative foundations of the UN Charter—while underscoring commitments to international peace, security, and the rulebased international system. The emphasis placed by the Heads of State of the Organization of Turkic States (OTS) on international law, peace, security, and collective welfare in the introductory section of the document signals a deliberate effort to ground the Turkic world's strategic outlook within widely accepted global norms. Moreover, the invocation of "universal values" illustrates an aspiration to develop a political vision that is compatible with the broader international community and to act as a constructive and responsible participant in global affairs. While the Vision–2040 draws its legitimacy from the shared language, culture, and historical experience of Turkic peoples, it simultaneously stresses that these common values are compatible with, rather than opposed to, universal norms.

Within this framework, the Turkic World Vision–2040 assigns a central role to the Organization of Turkic States, designating it as the primary institutional actor responsible for advancing both national capacities of member states and collective strength of the Turkic world. This objective is structured around four core pillars: (i) political and security cooperation, (ii) economic and sectoral cooperation, (iii) people-to-people cooperation, and (iv) cooperation with external partners. Each of these pillars is elaborated through distinct sections and thematic subheadings, providing a structured roadmap for multidimensional collaboration.

The Political and Security Cooperation pillar places particular emphasis on the rule of law and on en-

hanced engagement with other international and regional organizations, including the European Union and the United Nations. A key component of this pillar is the commitment to joint action against transnational threats that undermine international peace and security, such as terrorism, drug trafficking, human trafficking, arms smuggling, and cybercrime. By prioritizing cooperation in these areas, the Vision–2040 signals a clear intention to prevent the Turkic region from becoming a permissive environment for organized crime and illicit networks over the coming decades. In this context, Baranyi (2022: 121–136) highlights the distinctive position of Hungary, which, as a member of the European Union and an observer state of the OTS, occupies a unique bridging role. Despite geographical distance, Hungary shares a range of common interests with OTS members and, through its participation in EU decision-making processes, possesses the potential to contribute to shaping EU policies in ways that foster greater understanding and cooperation with the Turkic world—particularly in areas such as security, migration, and energy [Kocaman, Omer 2021].

The Economic and Sectoral Cooperation pillar of the Turkic World Vision–2040 is particularly significant in that it seeks to translate the historical, cultural, and social bonds of the Turkic world into tangible policy outcomes and measurable economic gains. By aligning existing partnerships among Turkic states with clearly defined economic objectives and joint projects, this pillar aims to deepen cooperation and enhance collective economic capacity. Strengthened economic coordination is expected to bolster the Turkic world's standing as a confident regional and, potentially, global actor. Given that economic integration remained relatively underdeveloped in the post-1991 period, the articulation of a comprehensive economic agenda in Vision–2040 represents a critical step toward reinforcing political cooperation across the Turkic world. Importantly, this pillar moves beyond declaratory rhetoric by structuring cooperation around eight concrete domains: (i) economic cooperation, (ii) transport and customs, (iii) information and communication technologies, (iv) energy, (v) tourism, (vi) health, (vii) environment, and (viii) agriculture, each of which is framed with specific targets and implementation priorities.

The People-to-People Cooperation pillar reflects the Organization of Turkic States' recognition of the growing influence of individuals and civil society actors in contemporary international relations. In line with global trends, this section places particular emphasis not only on non-governmental organizations—such as associations, unions, and foundations—but also on media institutions and diaspora communities as key facilitators of social connectivity and transnational interaction.

Structured around six sub-fields—(i) culture, (ii) education and science, (iii) youth and sports, (iv) diaspora, (v) information and media, and (vi) civil society organizations—this pillar aims to foster a human-centered social space within the Turkic world. The focus on societal interaction and grassroots engagement constitutes one of the most distinctive and forward-looking dimensions of the Turkic World Vision–2040.

Within this broader people-to-people framework, Education and Science occupies a central role as a strategic driver of long-term integration. The Vision–2040 calls for the harmonization of curricula and credit systems in higher education to facilitate academic cooperation among OTS member states, alongside enhanced collaboration in diploma recognition and academic qualification frameworks. It further emphasizes the modernization of national education systems in accordance with international standards, including the adoption of innovative teaching methods, the promotion of critical thinking, and the effective use of digital technologies. In parallel, the document advocates intensified scientific and analytical research on shared Turkic history, culture, language, literature, and geography, as well as the inclusion of elective courses on these subjects within national school curricula.

The Vision–2040 also seeks to operationalize the Turkic Higher Education Space through initiatives such as the Orkhun Process Exchange Program and by strengthening the role of the Turkic Universities Union (TURKUNIB) as a principal coordination mechanism. To enhance academic mobility, it proposes joint policies and instruments—including twinning arrangements and competitive scientific events—to support the exchange of students, researchers, and faculty members. Additional measures include the development of modern educational materials on common Turkic heritage, the creation of accessible scientific publication databases and a shared international indexing system for OTS academic journals, and the exchange of best practices in entrepreneurship and vocational training. Finally, the Vision–2040 promotes joint fundamental, applied, innovative, and start-up projects, the development of a common innovation ecosystem, technology transfer among member states, and the commercialization of scientific outputs as key components of sustainable and knowledge-based cooperation.

CONCLUSION

Following the dissolution of the Soviet Union in 1991, five Turkic republics—Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, and Turkmenistan—emerged as independent states, marking a transformative moment for the political and institutional configuration of the Turkic world. Together with the Republic of Türkiye, established in 1923, and the Turkish Republic of Northern Cyprus (TRNC), which proclaimed independence in 1983 and is recognized solely by Türkiye, the concept of a geographically expansive and demographically significant Turkic world gained increasing prominence in political and academic discourse. These debates gradually evolved from abstract discussions into concrete institutional arrangements, culminating in the establishment of the Organization of Turkic States (OTS) by Azerbaijan, Kazakhstan, Kyrgyzstan, and Türkiye through the Nakhchivan Agreement of 2009. Subsequent developments—most notably Uzbekistan's accession as a full member in 2019, the organization's rebranding as the Organization of Turkic States in 2021, and the inclusion of Hungary (2018), Turkmenistan (2021), and the TRNC (2022) as observer states—have significantly enhanced the institutional capacity

and international visibility of the OTS. As its organizational framework has matured, the OTS has emerged as a more assertive actor in international politics, rendering its political orientation and long-term strategic vision increasingly consequential. This need for a comprehensive roadmap has been addressed through the articulation of the Turkic World Vision–2040.

Announced by the Heads of State of the Organization of Turkic States, the Turkic World Vision–2040 is designed to guide the organization's priorities, evolution, and strategic direction over the next two decades. The document seeks to anchor cooperation among OTS member states within a coherent and forward-looking political framework. To this end, it structures cooperation around four principal pillars—(i) political and security cooperation, (ii) economic and sectoral cooperation, (iii) people-topeople cooperation, and (iv) cooperation with external partners—further elaborated through eighteen thematic sub-areas. While the Vision–2040 is notable for its breadth and level of detail, it has also prompted debate regarding the practical realization of its ambitious objectives. As Yesevi (2022: 21) observes, although the document was prepared with considerable care and comprehensiveness, it raises questions concerning the mechanisms through which its wide-ranging goals can be effectively implemented [Kocaman, Omer (2021)]

From a theoretical perspective, neofunctionalism offers a compelling framework for understanding both the evolution of cooperation among Turkic states and the institutional development of the Organization of Turkic States. A central premise of neofunctionalist theory is that integration in one policy domain tends to generate spillover effects into adjacent areas, thereby fostering a cumulative and self-reinforcing integration process. The experience of the Turkic world provides several illustrative examples of this dynamic. Initial efforts to deepen cultural cooperation have gradually expanded into collaboration in education and scientific research. Institutions such as TURKSOY not only facilitate cultural exchange but also contribute to educational integration by promoting shared curricula, publishing common history textbooks, and organizing museum-based activities that simultaneously reinforce cultural awareness and educational linkages. These developments exemplify functional spillover, whereby initiatives designed for a specific sector produce integrative effects beyond their original scope. In this respect, the emergence and consolidation of the OTS can be interpreted through a neofunctionalist lens.

Similarly, economic integration within the OTS context has generated spillover into other strategic sectors, most notably transportation and energy. Economic imperatives have underpinned initiatives such as the Sister Ports Projects, the construction of natural gas pipelines, and the launch of freight rail connections among member states. While these projects are primarily motivated by economic considerations, they necessitate policy coordination and institutional cooperation in related fields, thereby deepening overall integration. Consequently, economic collaboration functions as a catalyst for broader sectoral convergence, reinforcing the relevance of functional spillover in the Turkic case. Taken together, these patterns suggest that neofunctionalism provides a persuasive explanation for both the formation and the ongoing functioning of the Organization of Turkic States, capturing the incremental and interconnected nature of integration within the Turkic world.

References

1. Akgul, Acikmese, S. (2004). "Uluslararasi iliskiler teorileri isibinda Avrupa butunlesmesi". Uluslararası Iliskiler, 1(1): 1-32.

2. Beylur, Suat (2021). "A new turning point in the integration of the Turkic World: Turkic World Vision2040", Weekly e-Bulletin No. 331, Eurasian Research Institute. Retrieved from https://www.eurasian-research.org/wp-content/ uploads/2021/12/Weekly-e-bulletin-29.11.2021-05.12.2021-No-331.pdf. Accessed: 12.05.2023.

3. Baranyi, Tamás P. (2022). "Hungary's role in the Organization of Turkic States as an observer state: Limitations and opportunities". Perceptions, 27(1): 121136.

4. Kocaman, Omer (2021). "Cok tarafli is birligi'nin karsilastigi zorluklar ve bolgesel uluslararasi kuruluslarin artan onemi: Turk Konseyi ornegi (The challenges faced by multilateral cooperation and the increasing importance of regional international organizations: The example of the Turkic Council)". Bagimsizliklarinin 30. Yilinda Turk Cumhuriyetleri-Bolgesel Politika (Turkic Republics in the 30th Anniversary of Independence-Regional Policy). Ankara: Nobel Yay.

5. Kocatepe, Omer Faruk (2022). Turk Devletleri Teskilati: Politik ve Askeri is Birligi (Turkic States Organization: Political and Military Cooperation). Ankara: Nobel Yay.

6. Kostem, Seckin (2017). "When Can Idea Entrepreneurs Influence Foreign Policy? Explaining the Rise of the "Turkic World" in Turkish Foreign Policy". Foreign Policy Analysis, No. 13: 722–740.

7. Mercan, Sezgin S. (2011). "Siyasal butunlesme kuramlari isiginda AB genislemesi" (EU enlargement in the light of political integration theories). Ankara Avrupa Çalışmaları Dergisi, 10(1): 67-83.

8. Musabay Baki, Pelin (2022). "Turkic World Vision–2040: A step forward for the resilience of Turkic cooperation". Perceptions, 27(1): 26-52.

9. Parliamentary Assembly of Turkic States (2023). "About TURKPA". Retrieved from https://turkpa.org/en. Accessed: 02.04.2023.

10. Schimmelfennig, Frank and Daniel C. Thomas (2011). "Normative institutionalism and EU foreign policy in comparative perspective". International Politics, 46(4): 177-191.

11. Schneider, Gerald and Anastasia Ershova (2018). Rational Choice Institutionalism and European Integration. Oxford: Oxford University Press.

12. Suddaby, Roy, William M. Foster and Albert J. Mills (2014). History and Institutions. Organizations in Time: History, Theory, Methods (Ed. M. Bucheli ve D.Wadhwani). Oxford: Oxford University Press.

13. The International Organization of Turkic Culture (2023). "History". Retrieved From https://www.turksoy.org/en-US. Accessed: 02.04.2023.

14. Spring 2023 The International Turkic Culture and Heritage Foundation (2023). “The Inter-Vol. 5, No. 2. National Turkic Culture and Heritage Foundation (ITCHF)”. Retrieved from https://itchf.org/en/. Accessed: 02.04.2023.

15. The Organization of Turkic States (2020). “Nakhchivan Agreement”. Retrieved from https://turkicstates.org/assets/dokuman/Nahngilizce1.pdf. Accessed: 02.04.2023.

16. The Organization of Turkic States (2021). “Organization”. Retrieved from https://www.turkicstates.org/en. Accessed: 02.04.2023.

17. The Organization of Turkic States (2022). “Baghdad Amreyev is appointed as the President of the

18. Turkic Investment Fund by the Leaders of OTS”. Retrieved from https://turkicstates.org/en/haberler/baghdad-amreyev-is-appointed-as-thepresident-of-the-turkicinvestment-fund-by-the-leaders-of-ots_2682. Accessed: 02.04.2023.

19. The Organization of Turkic States (2023). “The Turkic World Vision – 2040”. Retrieved from https: 2023//turkicstates.org/assets/pdf/haberler/turkic-world-vision-2040-2396-97.pdf. Accessed: 02.04.2023.

20. Yaldiz, Firat and Cinar Ozen (2021). “Türkiye – Turk cumhuriyetleri iliskileri (1991-2021) (Türkiye Turkic republics relations (1991-2021))”. Bağımsızlıklarının 30. Yılında Türk CumhuriyetleriKüresel Politika. Ankara: Nobel Yay. 15-38.

21. Yesevi, Cagla Gul (2022). “Examining the organization of Turkic States: A teacher and norm-creator”.

22. Perceptions, 27(1): 2-25.

SOCIAL SCIENCES

EVALUATION OF INNOVATION FROM A STRATEGIC MANAGEMENT PERSPECTIVE AND SMES

Cagiran Kendirli H.
Asist. Prof. Dr.
Hitit University, FEAS, Department of Management, Turkiye
Arli S.
Hitit University, FEAS, Department of Management, Turkiye
DOI: 10.5281/zenodo.19327353

ABSTRACT

The high level of innovation resulting from globalization places companies in an extremely competitive environment. Only those companies that make the most of information technology and differentiate themselves from their competitors through differentiated products and services can survive. To thrive, they must constantly innovate and adapt to changing conditions. Strategic management decisions are crucial to these innovations and changes. One such decision is innovation itself. Although innovation and strategic management are fundamentally different concepts, they are closely related. In today's dynamic world, companies need strategic management awareness and the effective implementation of innovation processes to survive and grow in highly competitive markets. In today's globalized world, many companies are forced to renew their internal structures due to changing market demands, increasing competition, shorter product life cycles, and technological advances. This study examines the relationship between strategic management and innovation in light of key conceptual frameworks and insights from the literature.

Keywords: Management, Strategic Management, Innovation, Innovation in Management, SMEs.

1. INTRODUCTION

The accelerated global change since the Industrial Revolution, particularly in the Information Age, has created a structure in which technological developments affect virtually all sectors simultaneously, and information and communication technologies have become the dominant force. This rapid change transforms organizational and social structures into constantly evolving dynamic systems and compels companies to closely monitor economic, political, social, and technological changes in their internal and external environments (Kılıç, 2023: 70). At the same time, the development of communication and transportation infrastructure, the shift in marketing understanding, globalization, and increasing international competition have intensified competitive pressure among companies, necessitating the adoption of more innovative approaches and practices to secure a competitive edge (Hancıoğlu & Yeşilaydın, 2016: 106–107).

In this context, strategy and strategic management constitute the fundamental management framework that companies rely on to survive in an uncertain and highly competitive environment. In management literature, strategy is understood as the entirety of paths and methods that companies pursue to achieve their objectives in highly competitive markets. Over time, these paths and methods have paved the way for the emergence of an independent discipline: strategic planning and its further development, strategic management (Aktan, 2008: 6). The success of strategic management activities depends on the company's ability to identify and implement strategies that give it a competitive advantage; in other words, on its ability to establish a lasting balance between changing environmental conditions and its internal resources and capabilities (Aslan, 2019: 9).

Innovation, on the other hand, has become a crucial factor for the competitiveness of countries, industries, and companies in modern economies. Innovation is considered key to economic growth, increased employment, and a higher quality of life, and is essential for companies in virtually all sectors at the product, service, and process levels (Satı & Işık, 2011: 538; Hancıoğlu & Yeşilaydın, 2016: 106–107). While Schumpeter understands innovation as a process that encompasses new technologies and new business models and provides competitive advantages, Rogers (1995) defines innovation as an idea, practice, or object that is perceived as new by individuals. Damanpour interprets innovation as the process of adapting, developing, and creating new ideas that influence a company's success; Trott, on the other hand, views innovation within the framework of managing all activities related to idea generation, technology development, the design of new or improved products, processes, and facilities, as well as the marketing process (Damanpour, 1991; Trott, 1998).

At this point, it becomes clear that innovation efforts have evolved from incidental or purely technical applications left to the research and development department to a strategic management area encompassing the entire organization. Innovation management means that the company holistically organizes its technology, business processes (customers, suppliers, financial and external resources, etc.), as well as its culture, communication, and organizational structure with regard to the human factor, in such a way as to support and promote innovation (Kalay et al., 2015: 68). In this context, the success of innovations depends not only on the available human resources, technologies, information, and equipment, but also on the organization's ability to manage these resources from a strategic perspective (Kalay et al., 2015: 67–68).

The relationship between strategic management and innovation is not simply a juxtaposition of two separate areas. In today's economic environment, organizations must create a certain synergy between strategy and innovation to generate differentiated added value (Satı & Işık, 2011: 539). The concept of strategic innovation expresses precisely this synergy. It refers to the integration of a company's strategic direction with innovative activities and leads to fundamental changes in the business model, value proposition, and market positioning that extend beyond existing products and processes (Hancıoğlu & Yeşilaydın, 2016: 105–106; Satı & Işık, 2011: 539–540). As Kılıç (2023: 70) emphasizes, strategic innovation provides a framework that integrates all types of innovation, thus enabling sustainability, long-term profitability, competitive advantages, and diversification. It also prompts the company to consider the entire system in addition to the product and process. SMEs are an important aspect of this strategic perspective.

Although small and medium-sized enterprises (SMEs) make a crucial contribution to the economy in terms of employment, value creation, and entrepreneurship, they are particularly exposed to intense competitive pressure, resource scarcity, and uncertainty. Çetinkaya and Gülbahar (2019: 349–350) note that strategic management awareness and the successful implementation of innovation processes have become essential for both the survival and growth of SMEs. However, few studies examine the synergy between strategic management and innovation in SMEs. This underscores the need for theoretical and applied research that addresses the relationship between strategic management and innovation, especially from the perspective of strategic innovation (Çetinkaya & Gülbahar, 2019: 350; Kalay et al., 2015: 67).

[Note: The last sentence about strategic management and innovation is unrelated and appears to be a separate, unrelated statement. It has been omitted from the translation.] The aim of this article is to examine the relationship between strategic management and innovation in light of prominent conceptual frameworks and findings from the literature and to discuss, from a theoretical perspective, organizations' efforts to achieve sustainable competitive advantages, particularly through the concept of strategic innovation. The study first addresses the concepts of strategic management and innovation. It then examines the dimensions of strategic innovation, its position within the strategic management process, and its relationship to organizational performance. The final section presents discussions and recommendations based on findings from the literature, offering assessments of how strategic management and innovation can be addressed in organizations through an integrated approach.

2. Theoretical Foundations of Strategic Management and Innovation

2.1. The Concept of Strategy and Strategic Management

In an increasingly competitive environment, companies achieve their goals not by chance, but through deliberate decisions and a long-term perspective. In this context, strategy is understood as a set of orientations and decisions that demonstrate how defined goals can be achieved with maximum performance and limited resources (Aslan, 2019: 10).

Strategy determines the areas in which the company will operate, the competencies it will emphasize, and the methods and approaches that will differentiate it from its competitors, taking into account the opportunities and threats of its environment.

Strategic management, on the other hand, is a dynamic process that encompasses the planning, implementation, and continuous review of this strategic direction. As a combination of management and strategy concepts, strategic management is a comprehensive management approach that includes setting goals in line with the company's mission and vision, analyzing external conditions and internal capacities, developing suitable strategic alternatives, and implementing them throughout the organization (Çetinkaya and Gülbahar, 2019: 350).

Strategy In this context, strategic management is understood not only as a planning activity but also as a continuous decision-making process in which implementation, monitoring, and learning are mutually dependent.

In competitive economic systems, strategy is a fundamental management tool that enables companies to adapt to environmental changes and even actively manage them. The success of a strategy depends on the quality of the company's reciprocal adaptation to its environment, the extent of its ability to develop innovative approaches to achieve this adaptation, and the extent of its ability to control change (Satı and Işık, 2011: 539–540).

Therefore, strategic management requires companies to prepare not only for their current situation but also for possible future scenarios; it focuses on flexibility, learning capacity, and innovation under uncertainty (Aktan, 2008: 6).

In today's understanding, strategic management is no longer simply about creating long-term plans in the classical sense. In an environment of increasing uncertainty, accelerated technological change, and frequently shifting customer expectations, strategic management offers a holistic framework. This framework aligns the company's vision with stakeholder interests, develops competencies that secure competitive advantages, and supports these competencies through innovative practices. From this perspective, strategic management has evolved into one of the fundamental management philosophies that activates a company's innovation potential and enables sustainable competitive advantages (Aslan, 2019: 10–12; Çetinkaya and Gülbahar, 2019: 350).

2.2. The Concept and Types of Innovation

In economic literature, innovation is not understood merely as a narrowly defined technical activity in the sense of "novelty," but rather as the process of implementing a new or significantly improved product, process, marketing method, or organizational practice that generates economic and social value (OECD, 2005).

In this sense, innovation is a dynamic process that encompasses both the outcome of a new product or application and the phases of creative thinking, development, and commercialization that lead to this outcome (Morris, 2013: 6). According to Drucker, innovation is a function that constitutes the essence of entrepreneurship; it is the fundamental tool that reveals the ability to create wealth in situations such as the creation of a new business, the transformation of public institutions, or the establishment of a new enterprise by an individual (Drucker, 1985: 5–6).

In this sense, innovation is a function that constitutes the essence of entrepreneurship. In the definitions cited by Tankişi, innovation is also emphasized as the creation of something new, the significant differentiation of an existing product or process, and the transformation of this novelty into a marketable value proposition (Tankişi, 2019: 57–58).

Commonly, innovation is understood as the successful implementation of new ideas into economic or social value; therefore, innovation cannot be reduced solely to the field of science and technology, but only gains significance through value creation (Tankişi, 2019: 57–58).

For companies, innovation is an important competitive tool that reduces costs, increases efficiency and profitability, and enables entry into new markets as well as expansion into existing ones (Özgür Güler and Kanber, 2011: 62).

The European Commission's Green Paper on Innovation emphasizes that innovation is a driving force for achieving long-term corporate goals, enables the emergence of new industries, contributes to the renewal of industrial structures, and forms the core of entrepreneurial spirit. The same text emphasizes that innovation is not only a technical process but also a transformative instrument expected to provide solutions to numerous societal problems—from healthcare to environmental protection (European Commission, 1995).

The degree of innovation depends on the impact of the changes it brings about on the market and the environment. Therefore, innovation is always market-oriented for companies; for innovations to be considered as such within an organization, they depend on their ability to generate commercial revenue and competitiveness (Drucker, 1985: 30–31).

The ability of companies to adapt to changing technological conditions and customer expectations, and to transform environmental changes from a threat into an opportunity, depends significantly on their openness to innovation activities (Uzkurt, 2010). The types of innovation are classified in the literature according to various criteria. According to the widely accepted OECD classification, innovation is divided into four main categories: product innovation, process innovation, marketing innovation, and organizational innovation (Çetinkaya and Gülbahar, 2019: 353).

Product innovation refers to the development of new products whose technical specifications, content, materials, software, or functional characteristics differ significantly. The goal is to reduce costs and gain a competitive advantage while simultaneously increasing product performance and variety (Çetinkaya and Gülbahar, 2019: 353–354). Process innovation encompasses fundamental changes to a company's production or service processes using new technologies, equipment, and software to increase efficiency and reduce unit costs (Aktaş, 2018).

Marketing innovation focuses on better meeting customer needs, opening up new markets, or repositioning products through the use of previously unused methods in design, packaging, positioning, advertising, or pricing. Organizational innovation, on the other hand, is the application of a new organizational method in the business practices, workplace organization, or external relations of the company; it includes innovative arrangements in areas such as division of labor, distribution of authority and responsibility, and integration of different activities (Çetinkaya and Gülbahar, 2019: 353-354).

Other classifications also group innovation according to its application area, impact, and scope of change. For example, according to the classification adapted by Tankişi, Ünal, and Kılınç from Sattler, types of innovation are considered along three dimensions: product and process innovations with regard to application; social and organizational innovations with regard to scope; and radical and incremental innovations with regard to the degree of change (Sattler, 2011: 10–11; Ünal and Kılınç, 2016: 102).

Innovation is thus conceptualized as a comprehensive field of transformation that is not merely a technical innovation but extends from the organization's products to its processes, from its marketing activities to its organizational structure.

2.3. The Concept of Strategic Innovation

In today's environment of intensified global competition and blurred market boundaries, traditional competitive strategies are often no longer sufficient for companies. As the study by Hancıoğlu and Yeşilaydın shows, the rapid development of communication and information technologies, changing customer structures, and globalization are forcing companies to rethink their existing strategic structures and marketing approaches. Innovation is at the heart of this new competitive paradigm (Hancıoğlu and Yeşilaydın, 2016: 106–108).

Strategic innovation is a competitive approach driven by the synergy between corporate strategies and a company's innovative capacity. The goal is to create new value for customers, surprise competitors, expand the market, and tap into new markets (Hamel, 1998: 8).

Schlegelmilch et al. Strategic innovation is defined as the reconceptualization of business models and the transformation of existing markets in response to changing competitive rules (Schlegelmilch et al., 2003: 117–118). A common denominator of these definitions

is that strategic innovation focuses on fundamental changes to the business model, the value creation logic, and the market structure, rather than on product innovations.

While Govindarajan and Trimble view strategic innovation as a form of innovation that requires abandoning existing practices in value chain design, conceptualizing customer value, and identifying potential customers, Drejer assesses strategic innovation as a new business concept that necessitates a rethinking of the entire company, including its business systems, core competencies, and market structure (Govindarajan and Trimble, 2004: 69; Drejer, 2006: 145).

Abraham and Knight, on the other hand, interpret strategic innovation as an effort to expand the market, create new markets, and restructure the entire business strategy, rather than simply reacting to customer demand (Abraham and Knight, 2001: 22). Based on these approaches, three main outcomes of strategic innovation can be derived: the development of new business models, the emergence of new markets or the transformation of existing markets, and the creation of added value for customers and companies (Hancıoğlu and Yeşilaydın, 2016: 109–196).

Markides' study, which examined successful companies from various industries, also shows that strategic innovation is at the heart of the sustainable success of companies such as Unilever, Canon, Texas Instruments, Apple, Starbucks, and Yamaha (Markides, 1997: 9–10).

Markides' study, which examined successful companies from various industries, also shows that strategic innovation is at the core of the sustainable success of companies like Unilever, Canon, Texas Instruments, Apple, Starbucks, and Yamaha (Markides, 1997: 9–10).

When considering the components of strategic innovation, it is emphasized that top-level leaders must master strategic thinking for the present and future, strike a balance between innovation and effectiveness, and be able to conduct creative idea generation and analytical evaluation in parallel (Drejer, 2006: 144–145).

In the study by Schlegelmilch et al., based on the MIMIC model, four fundamental factors for the development of strategic innovation are identified: culture, processes, people, and resources. The components of strategic innovation are summarized under the terms customer value and competitive positioning (Schlegelmilch et al., 2003: 119–127).

In summary, strategic innovation represents an approach that redefines the relationship between corporate strategy and innovative capacity. Competitive advantage is based not only on improvements to existing products and processes, but also on a fundamental questioning of the business model and market structure. Strategic management and innovation should therefore not be viewed as two separate areas, but as two complementary dimensions that determine the long-term success of the company, influence each other and must be considered together (Satı and Işık, 2011: 540-542; Hancıoğlu and Yeşilaydın, 2016: 106-110).

3. Synergy Between Strategic Management and Innovation: Strategic Innovation Approaches

3.1. Synergy Between Strategic Management and Innovation

Strategic management and innovation, whose conceptual framework was outlined in the first chapter, are not viewed as two separate areas that develop independently in practice, but rather as different facets of the same whole. Strategic management is a process that aims to determine the long-term direction of the organization by systematically evaluating the strong and weak signals from the internal and external environment and developing corresponding goals and strategies. This process involves not only making decisions about the future of the organization, but also deciding how resources are allocated and in which areas they are concentrated (Bircan, 2003; Diken, Öge & Aslan, 2006).

Innovation management, on the other hand, is a more specialized management field that considers technological developments, changes in production processes, and the organization's internal and external relationships together, and guides the emergence and institutionalization of innovations. Satı (2010) describes innovation management as an integrated management process that combines a company's resources—knowledge, technology, human capital, and financial strength—to create innovations. This process encompasses planning, implementation, monitoring, and results evaluation (Satı & Işık, 2011: 543).

This definition clarifies that strategic management and innovation management represent two fundamental management functions that complement each other and operate on the same foundation. According to Satı and Işık (2011: 540), increasing competitive pressure, accelerated technological change, and the volatility of market dynamics are forcing companies to move beyond the traditional understanding of innovation. Innovation has become an indispensable tool for organizations to gain a competitive edge and respond flexibly and proactively to customer needs. Therefore, innovation decisions should not be left to chance. They should be addressed within the framework of an innovation strategy that aligns with the company's overall strategy. In other words, there is a strong interdependence between fundamental corporate strategies and innovation strategies.

In the context of innovation, the fundamental corporate strategies and innovation strategies are highly interdependent. The authors emphasize that in competitive economic environments, strategy is essentially a management tool designed to ensure innovation, progress, and the company's adaptation to its environment. For effective innovation management, the concepts of "strategic action" and "leadership" are crucial success factors; companies without a solid strategic framework cannot consistently and holistically implement the necessary steps of the innovation process (Cormican & O'Sullivan, 2004).

This emphasis underscores the need to establish an organic link between strategic management and innovation management. At this point, the concept of strategic innovation emerges as an overarching term that

expresses the intersection of innovation logic and corporate strategies. Hancıoğlu and Yeşilaydın (2016) understand strategic innovation as an approach that arises from the interplay of innovative thinking and a company's long-term strategic orientation, offering a new value proposition to customers, stakeholders, and sometimes even entire industries. In this context, strategic innovation is not limited to the development of new products or processes, but represents a more comprehensive transformation that includes the reinterpretation of the business model, value creation methods, and rules of competition (Hancıoğlu & Yeşilaydın, 2016: 105–107).

The authors argue that strategic innovation enables companies to surprise their competitors, tap into new markets, and change the rules of the game in existing markets. In this way, companies can not only adapt to existing competitive conditions but also actively shape them. This transformative effect of strategic innovation requires a strategic link between both internal capabilities and external opportunities (Hancıoğlu & Yeşilaydın, 2016: 105–107).

Tankişi's (2018) study in the automotive sector emphasizes that innovation is a value directly linked to a company's vitality and its adaptability to environmental changes. The study shows that companies that successfully manage innovation and support this process through strategic leadership have significantly higher chances of survival and growth under competitive pressure. Conversely, companies that resist innovation lose strength over time because they cannot adapt to changing conditions (Tankişi, 2018: 41–42). In this sense, strategic leadership plays a crucial role, as it identifies innovation opportunities and aligns them with the company's strategic direction (Tankişi, 2018: 185).

Considering these findings together, it becomes clear that there is not only a supportive but also a mutually reinforcing synergy between strategic management and innovation. While strategic management establishes the appropriate direction, priorities, and resource allocation for innovation, innovation acts as a dynamic instrument that ensures the feasibility and sustainability of strategic decisions. The strategic innovation approach offers a holistic management style that strengthens a company's competitive position by integrating these two areas.

3.2. Innovation Strategies in Terms of Competitive Advantage

Globalization, technological progress, and the rapid integration of markets are intensifying competition between companies at both local and international levels. In this environment, traditional cost-cutting or differentiation strategies alone are no longer sufficient; they must be rethought from an innovative perspective. Hancıoğlu and Yeşilaydın (2016: 106–108) observe that in today's business world, innovation is not merely an "add-on activity" but rather one of the fundamental tools for achieving a sustainable competitive advantage. Innovation reduces costs, increases efficiency, productivity, and profitability, contributes to improved product and service quality, and facilitates market entry. The European Commission's 1995 strategy paper, the "Green Paper on Innovation," describes the role of innovation for businesses and states. According to this document, innovation acts as a driving force for achieving long-term corporate goals, enables the emergence of new economic activities and sectors, and leads to the renewal of industrial structures. Innovation is at the heart of entrepreneurship. Innovation is understood not merely as an economic mechanism or a technical process, but as an instrument for solving societal problems (European Commission, 1995).

In this context, the decisive competitive advantage lies in the fact that innovation activities are not random experiments, but are carried out within the framework of innovation strategies that align with the company's overall direction. Satı and Işık (2011: 540) emphasize that the innovation strategy is a management framework that defines the fundamental steps and progress the company undertakes in the context of innovation. Depending on their innovation expectations, companies—analogous to defining their overall strategy—must develop an innovation strategy, taking into account their long-term goals, risk tolerance, market position, and technological orientation.

This strategy guides, on the one hand, the development of new products and services, the improvement of processes, and the redesign of business models; on the other hand, it requires adapting the organizational structure, culture, and human resources to the needs of these innovations. Satı and Işık (2011: 540) note that innovation has become a key element for economic growth, job creation, and quality of life. Therefore, they argue that the effectiveness of the innovation management process should be increased to improve the success of innovation efforts.

Kalay et al. (2015: 67–69) collected data from 132 managers in 66 companies in the TRB2 region to investigate the role of strategic innovation management in terms of competitive advantage and to analyze the key dimensions of innovation performance. The study examined the relationship between innovation performance and “strategic innovation management practices,” which comprise components such as innovation strategy, organizational structure, innovation culture, technological capabilities, and customer-supplier relationships. The results show that innovation strategy and organizational structure, in particular, have a significant and positive impact on innovation performance; the effect of other dimensions, however, is less pronounced.

This finding highlights that innovation strategy, in terms of competitive advantage, is not merely a "technical" decision, but also a management decision that impacts the entire organization. Innovation efforts that are not clearly defined strategically and not aligned with the organizational structure struggle to focus on their objective. Conversely, a clear innovation strategy and a flexible organizational structure that supports this strategy facilitate the transformation of innovation into a competitive advantage. Tankişi (2018: 41–42) notes in his study that innovation is an effective tool for enhancing the competitiveness of companies and plays a crucial role in increasing profit, cash flow, and market share. The study observes that innovation is considered

a "powerful competitive weapon" in the literature, enabling companies to outperform their competitors in their respective industries. It is viewed as one of the fundamental ways to adapt to environmental changes and capitalize on new opportunities.

In conclusion, Kılıç's study (2023) highlights several key points for the strategic management of innovation processes. According to the study, it is necessary to expand resources for creating new products and jobs, shorten development and implementation cycles, rapidly integrate new technologies into the organizational structure, and foster a corporate climate in which innovations of all kinds can flourish. Furthermore, reducing development gaps in production and management processes, implementing innovation-oriented management to increase return on investment, and systematically identifying and eliminating barriers to innovation are considered crucial for securing competitive advantages. These findings underscore the importance of innovation strategies from a competitive advantage perspective. When innovation is placed at the heart of competitive positioning, it becomes a holistic strategic decision requiring the redesign of both internal business processes and relationships with the external environment.

3.3. The Relationship Between Strategic Management and Innovation in SMEs

One of the areas where the synergy between innovation and strategic management is particularly important in practice is small and medium-sized enterprises (SMEs). SMEs are known to represent the vast majority of businesses in Turkey and worldwide; however, the number of studies on strategic management and innovation in this sector is comparatively small. Çetinkaya and Gülbahar (2019: 349–350) state that SMEs constitute 99.8% of businesses in Turkey and form the backbone of the economy in terms of indicators such as employment, value added, and exports. Based on this fact, the authors investigated the relationship between strategic management and innovation in SMEs across various sectors in Ankara. The study sample comprised 300 SME managers from 35 sectors; data were collected via questionnaires and face-to-face interviews. Two separate scales were used in the analyses to measure perceptions of strategic management and innovation. The relationships between the scores achieved on these scales were statistically examined (Çetinkaya & Gülbahar, 2019: 350–355).

The results show that SME managers' perceptions of strategic management and innovation are at a moderate level; nevertheless, a significant and positive correlation exists between the two variables. Pearson correlation coefficients demonstrate a positive and moderate correlation between the total scores on the strategic management scale and the total scores on the innovation scale. Structural equation modeling also shows that an improved perception of strategic management is associated with an improved perception of innovation (Çetinkaya & Gülbahar, 2019: 355).

These results suggest that a better understanding of strategic management in SMEs directly and positively influences their innovative capacity. Strategic management practices such as setting long-term goals, conducting environmental analyses, planning resource allocation, and aligning the organization with these goals promote the generation and implementation of innovative ideas. Conversely, strengthening innovation processes deepens the strategic perspectives of managers and increases companies' future-oriented decision-making capacity. The study by Kalay et al. (2015) in the TRB2 region also confirms the link between strategic innovation management and innovation performance in SMEs. The study found that strategic innovation management practices, such as innovation strategy and organizational structure, significantly increased the innovation performance of companies, mostly SMEs (Kalay et al., 2015: 67–69).

This finding supports the link between strategic management and innovation postulated by Çetinkaya and Gülbahar in the context of SMEs. The results of Tankişi (2018) also show a positive correlation between strategic leadership and innovation management processes in organizations similar to SMEs. It is emphasized that a management style that observes environmental trends, maintains open communication with employees, and is flexible and open to innovation is essential for the survival of the company, especially in industries with high competitive pressure and significant uncertainty (Tankişi, 2018: 134).

In summary, the relationship between strategic management and innovation in SMEs is characterized by a reciprocal and dynamic interaction. Strengthening strategic management approaches increases the innovative capacity of SMEs; conversely, developing innovation processes sharpens the strategic direction of these companies and thus strengthens their competitive position.

3.4. Strategic Innovation Management Practices and Innovation Performance

Strategic innovation management is based on an approach that understands the innovation process as a management domain encompassing all components of the organization and not limited solely to idea generation or R&D activities. In their model for explaining innovation performance, Kalay et al. (2015) examine strategic innovation management using five fundamental dimensions: innovation strategy, organizational structure, innovation culture, technological capabilities, and customer-supplier relationships. All of these dimensions were assessed as indicators of how innovation-friendly a company is and how intensively it promotes innovation (Kalay et al., 2015: 67–69).

Research also refers to the resource-based approach, which is prominent in the innovation literature. This approach posits that a company's unique and difficult-to-imitate resources, such as knowledge, experience, technology, and human capital, can be transformed into a competitive advantage through innovation. However, it is also emphasized that studies examining the relationship between innovation and business performance do not always yield consistent results. While some studies demonstrate the strong and positive impact of innovation on profitability and growth, others show that innovation investments do not always achieve the expected performance gains due to

cost pressures and uncertainty (Kalay et al., 2015: 67–69).

The results of the field study by Kalay and colleagues in the TRB2 region support this discussion with concrete data. The study found that the dimensions of innovation strategy and organizational structure positively and significantly influence innovation performance; in contrast, the effects of innovation culture, technological capabilities, and customer-supplier relationships were statistically weaker (Kalay et al., 2015: 69). This finding suggests that strategic alignment and organizational design are particularly important for improving innovation performance and that other dimensions should build upon this fundamental structure.

Satı and Işık (2011) view strategic innovation management not as a narrowly defined field focused solely on technology improvement, product development, or traditional cooperation networks, but as a process that compels a review of the company's entire business model. The authors argue that innovation must be "new to the company" and create economic value, and that the life cycles of companies change as soon as the innovative idea is implemented as a product, service, or business process (Satı & Işık, 2011: 540). The innovation strategy serves as a guideline for the organization, defining the areas in which it will innovate, the risks it will take, and the value proposition it will develop.

The authors emphasize that the effectiveness of innovation management must be increased to improve the success of innovation efforts. Rapid technological change is forcing companies to innovate more quickly, and innovation should therefore be considered a key element for economic growth, employment, and quality of life (Satı & Işık, 2011: 540). This emphasis demonstrates that strategic innovation management should consider not only short-term performance indicators but also the long-term sustainability of the company.

Tankişi's (2018) field study examines the performance dimension of strategic innovation management, particularly with regard to strategic leadership. The study notes that innovation is a "source of competitive advantage" for companies; however, poorly managed innovation processes can lead to adaptation problems and wasted resources. Participant statements indicate that practices such as a flexible organizational structure, an employee-centric management approach, continuous learning, and close monitoring of developments in the environment strengthen the innovation process (Tankişi, 2018: 41–42, 185).

Tankişi's (2018) field study examines the performance dimension of strategic innovation management, particularly with regard to strategic leadership. These practices illustrate that strategic innovation management should be considered not only in terms of structure, but also with regard to cultural and leadership dimensions. The study by Çetinkaya and Gülbahar (2019) on SMEs indirectly supports the link between strategic innovation management and innovation performance. The positive and moderate correlation between strategic management and innovation perception shows that developing strategic perspectives among managers also strengthens innovation processes (Çetinkaya & Gülbahar, 2019: 355). This suggests that the success of strategic innovation management practices is closely linked to formal structures and processes, but also to the mindset and perceptions of managers.

In summary, the relationship between strategic innovation management practices and innovation performance is multidimensional and conditional. While structural elements such as innovation strategy and organizational structure have a direct and strong impact on performance, elements such as corporate culture, leadership style, relationships with external stakeholders, and technological infrastructure play a supporting role within this basic structure. The literature shows that the innovation performance of companies, and thus their competitive advantages, are strengthened when the synergy between strategic management and innovation is properly structured, innovation is addressed at a strategic level, and it is supported by management.

4. Organizational Dimensions of the Relationship Between Strategic Management and Innovation

4.1. Strategic Leadership and Innovation Management

The link between strategic management and innovation is most evident in a company's top management and its leadership style. Finkelstein and Hambrick (2009) define strategic leaders as members of top management who play a crucial role in the company's long-term success, analyze the external environment, make key decisions, and are responsible for their implementation. According to Rowe (2001), a strategic leader is someone who can balance short-term financial performance with long-term competitive advantage while simultaneously formulating the company's vision. Elenkov (2005) connects strategic leadership with the company's ability to identify opportunities and threats in the environment, develop appropriate strategies, and align employees with these strategies.

Papadakis and Bourantas (1998) and Sosik et al. (2005) emphasize that the leader is the individual who shapes the company's culture and decision-making processes. In this context, the strategic leader is viewed not only as a decision-maker but also as an actor who holistically shapes the company's strategic direction, organizational structure, and innovative capacity. Tankişi's study of car dealerships shows that strategic leadership processes and innovation management practices are closely linked and that there is a positive correlation between the two (Tankişi, 2018: 3). According to the study, innovation management processes function more consistently in organizations with leaders who systematically analyze the environment, share the vision with employees, manage change, and take risks. This facilitates the creation, testing, and commercialization of new ideas (Tankişi, 2018: 3–4).

The crucial role of strategic leadership is closely linked to the quality of the tasks performed by the leader. Elenkov (2005) emphasizes that innovation is closely connected to the impact of leadership on organizational culture, organizational climate, and organizational learning. Barutçugil (2014) defines the strategic leader as the person who establishes and invests in the organization's core competencies, aligns employees toward common goals, and manages change processes.

From this perspective, the contribution of strategic leadership to innovation management lies in creating a climate in which creative ideas can emerge, lessons can be learned from mistakes, and organizational learning processes can be supported (Tankişi, 2018: 16–17).

Tankişi's (2018) findings highlight the influence of strategic leadership practices on the innovation management process, particularly in the dimensions of vision, communication, and change management. The car dealership managers participating in the study reported that applying strategic leadership principles led to faster innovation-related decisions, aligned resource allocation with these decisions, and increased employee willingness to participate in innovation initiatives (Tankişi, 2018: 26–27). As Yalçın and Ay (2007) also emphasized, innovative projects become concrete business outcomes, rather than remaining an abstract ideal, to the extent that strategic leaders can translate the company vision into employees' daily activities.

The literature on innovation management shows that the strategic leader in this phase acts not only as a visionary but also as a systems designer, creating and managing innovation processes. Satı and Işık (2011) define innovation management as a set of management activities that link technology, business processes, and interpersonal relationships in such a way as to foster innovation and manage innovation activities within a specific process. This definition clarifies the role of the strategic leader: they transform the company's vision into an innovation strategy, design the structures and processes appropriate for this strategy, and foster an organizational culture that enables innovation (Kılıç, 2023: 86–87).

The findings of Kalay et al. (2015) in their study of companies in the TRB2 region confirm this picture. The study revealed that innovation strategy and organizational structure positively influence innovation performance. Innovation culture, technological competence, and customer/supplier relationships showed no significant influence in the sample studied (Kalay et al., 2015: 68–69). This finding highlights the connection between strategic leadership and innovation management, particularly through the clarity of the strategy and the structural conditions. In other words, the ability of top management to define a strategy that clearly prioritizes innovation and to establish an organizational structure that supports this strategy directly impacts innovation performance (Kalay et al., 2015: 72–73).

In this context, strategic leadership becomes a key variable for formulating the innovation strategy, aligning resources with this strategy, and integrating employees into the innovation goals. The relationship between strategic management and innovation management is strengthened by the ability of leaders to analyze the environment, assess risks, and seize opportunities in a timely manner. and their ability to align internal structure and human resources with these opportunities (Tankişi, 2018: 29–30; Kılıç, 2023: 86–87).

4.2. Strategic Human Resources Management and Service Innovation

The sustainability of innovation at the organizational level largely depends on how human resources are managed. As Özsungur (2017) emphasizes in her service innovation-focused strategic human resources management model, strategic human resources management aims to build a bridge between the vision and mission of the business and its human resources practices. In this approach, human resources decisions are not seen merely as technical processes aimed at meeting short-term personnel needs, but as long-term investments supporting the organization's competitive strategy (Özsungur, 2017: 11–12).

Strategic human resources management positions human resources as a "strategic value" rather than a "cost element". As Bingöl (2014) also points out, attracting, retaining, developing, and monitoring the performance of qualified employees, when considered together with the strategic management process, constitutes sustainable competitive advantage. In Özsungur's model, this understanding is based on the assumption that human resources functions – recruitment, training and development, performance evaluation, career planning, and reward – should be designed in a way that is compatible with the innovation strategy. Thus, the organization aims to create a human resource profile that is open to innovation, ready for change, and focused on learning (Özsungur, 2017: 12).

Tankişi (2018: 29–30) also considers human resources as one of the key areas of competitive advantage for the business within the context of strategic leadership. The research emphasizes that human capital, consisting of elements such as knowledge, skills, experience, and motivation, directly affects the adaptability, flexibility, and innovation power of the business, especially in a rapidly changing technological environment. Finkelstein and Hambrick (2009) state that businesses competing in dynamic environments differentiate themselves not only with their physical assets or financial resources, but also with their human resources, which determine how they use these resources. In this framework, strategic human resources management serves as a framework that manages human capital in a way that is consistent with innovation goals.

Since innovation in the service sector is often shaped directly through employee-customer interaction, strategic human resources management is at the center of service innovation. Özsungur (2017) states that service innovation; It is stated that this is closely related to the capacity of employees to rethink service processes, transform customer feedback into creative solutions, and improve the service experience (Özsungur, 2017: 14). Baker and Sinkula (2009) and Storey and Kelly (2001) also show that the learning, knowledge sharing, and creativity levels of human resources are decisive in the success of service innovation (cited in Özsungur, 2017: 14–15). Therefore, an innovation-oriented human resources system should consider creativity and willingness to learn in the recruitment process; improve employees' problem-solving and customer-oriented thinking skills through training programs; and particularly encourage innovative behaviors in performance evaluation and reward mechanisms (Özsungur, 2017: 14–15).

In Özsungur's model, two important psychosocial elements supporting service innovation stand out: ethical leadership and psychological capital. Brown et al.

(2005) define ethical leadership as; While defining ethical leadership as a form of leadership that reflects values such as justice, honesty, reliability, and respect for employees in its behavior, Dhar (2016) revealed that ethical leadership positively influences employees' innovative behaviors both in and out of their roles. Accordingly, ethical leadership strengthens employees' trust in the organization and management, increasing their willingness to take risks and try new things; thus, it prepares the necessary psychological ground for service innovation (Özsungur, 2017: 15).

Psychological capital is a concept consisting of self-efficacy, hope, optimism, and resilience dimensions, expressing employees' capacity to withstand difficulties, try new approaches, and focus on goals (Bandura, 1997). Kim et al. (2016) and Bouckenooghe et al. (2015) show that employees with high psychological capital are more willing to engage in innovative behaviors, learn from mistakes, and actively participate in organizational change processes. In light of these findings, Özsungur (2017: 16–17) argues that strategic human resources management, which promotes service innovation, should be supported not only through technical skills and formal qualifications but also through practices aimed at strengthening employees' psychological capital. In conclusion, strategic human resources management represents the "human dimension" of the relationship with innovation; it directly contributes to service innovation through ethical leadership, psychological capital, and innovation-oriented HR policies. When strategic leadership and strategic HR management are considered together, a holistic management framework emerges that supports organizations' innovation capacity (Tankişi, 2018: 29–30; Özsungur, 2017: 11–17).

4.3. Organizational Structure, Organizational Culture, and Technological Competence

The relationship between strategic management and innovation is not limited solely to leadership and human resources; the structural characteristics of the organization, its cultural climate, and technological capabilities are also among the fundamental elements determining this relationship. Satı and Işık (2011) define innovation management as the firm's management of technology, business processes, and human relations in a way that supports and encourages innovation, and link innovation success to the resources available and the ability to manage these resources. Kalay et al. (2015), within this framework, consider innovation strategy, organizational structure, innovation culture, technological capability, and customer-supplier relations as the fundamental dimensions affecting firm innovation performance (Kalay et al., 2015: 68–69).

In the study conducted by Kalay et al. (2015: 72–73) on businesses in the TRB2 region, it was concluded that innovation strategy and organizational structure significantly and positively affect innovation performance; while innovation culture, technological capability, and customer and supplier relations did not have a direct effect within the sample. This finding indicates that, in order to support innovation at the organizational level, strategic orientation and structural arrangements must first be clarified. From a strategic management perspective, the innovation strategy provides a framework that determines in which areas, with which resources, and with which collaboration models the business will innovate; the organizational structure, on the other hand, shapes the network of relationships and decision-making mechanisms through which this strategy will be implemented (Kalay et al., 2015: 73–75).

Hancıoğlu and Yeşilaydın (2016: 105–106), addressing the concept of strategic innovation within the context of strategic management, draw attention to the synergy between innovative thinking and corporate strategies. The authors define strategic innovation as an approach that integrates strategy and innovation, aimed at creating new value for customers, catching competitors off guard, expanding the market, and creating new markets. According to Markides (1997), strategic innovation is a way of thinking that questions the established rules of competition in the sector, redefines what the customer "values," and combines these new value propositions with new business models. Sniukas (2007) also views strategic innovation as an effort to create differentiated value propositions for customers and stakeholders by going beyond the existing strategic position (cited in Hancıoğlu & Yeşilaydın, 2016: 109).

Hancıoğlu and Yeşilaydın (2016: 109) emphasize that strategic innovation is shaped around four fundamental elements at the organizational level: culture, processes, people, and resources. In organizations that embrace strategic innovation, the culture has a character that encourages risk-taking, is open to learning from mistakes, and supports creativity and flexibility. Processes have a systematic and repeatable structure for generating, evaluating, and implementing new ideas; innovative projects are managed within a specific method, rather than being random initiatives (Hancıoğlu & Yeşilaydın, 2016: 109–110). In terms of the human dimension, collaborative teams where employees from different disciplines work together, cross-functional projects, and strong communication channels come to the forefront. The resource dimension refers to the allocation of financial assets, technological infrastructure, and information resources in a manner consistent with strategic innovation goals, and securing the time and budget allocated to innovative projects (Hancıoğlu & Yeşilaydın, 2016: 110–111).

These elements concretize the relationship between strategic management and innovation management through organizational structure and culture. A flexible structure that strengthens horizontal relationships and reduces bureaucratic obstacles facilitates the circulation of new ideas, the flow of information between different departments, and rapid decision-making. Conversely, in overly hierarchical, rigid, and risk-averse structures, innovative ideas often get lost in the decision-making chain or are not sufficiently embraced (Kalay et al., 2015: 73–75; Hancıoğlu & Yeşilaydın, 2016: 109–110).

Technological competence is another decisive dimension in this relationship. Kalay et al. (2015: 68–69) define innovation management as the firm's ability to integrate technology, business processes, and human relations in a way that supports innovation; while they associate technological competence with the business's

capacity to monitor, select, adapt, and effectively use new technologies within the organization. Businesses with high technological competence can follow market and industry developments more closely, direct R&D and design activities according to strategic goals, and transform innovations in areas such as digitalization and automation into a competitive advantage. Conversely, weak technological competence can lead to innovation strategies remaining on paper and weaken the organization's long-term competitiveness (Kalay et al., 2015: 72–73).

To summarize the organizational dimensions of the strategic management-innovation relationship; strategic leadership, strategic human resources management, organizational structure, culture, and technological competence form complementary links. Leadership; While leadership represents the vision, strategy, and will to change, human resources organizes the human capital that will carry and sustain this vision. Organizational structure and culture show how innovation will be reflected in daily operations, through what mechanisms decisions will be made, and what kinds of behaviors employees will be rewarded. Technological competence, on the other hand, determines how all these efforts will be supported with concrete tools. Therefore, the relationship between strategic management and innovation is too multi-dimensional and dynamic to be reduced to a single variable. It has been observed that the synergy between strategic management and innovation is stronger in organizations where supportive practices in the areas of leadership, human resources, structure, culture, and technology are carried out together; conversely, when one of these elements is weak, the innovation capacity remains limited (Tankişi, 2018: 29–30; Özsungur, 2017: 11–17; Kalay et al., 2015: 68–75; Hancıoğlu & Yeşilaydın, 2016: 105–111). Therefore, it is critically important for businesses to rethink their strategic management approaches within a framework that holistically considers the organizational dimensions of innovation, in order to ensure the sustainability of their competitive advantage.

5. RESULT AND EVALUATION

This study reveals that strategic management and innovation are not two separate fields, but rather different sides of the same picture. Strategic management establishes the framework that determines where the business wants to go and what steps it will take along the way; innovation becomes one of the fundamental tools that fills this framework and ensures the business's survival in the competitive arena. Especially in an environment of high uncertainty, fierce competition, and rapid technological change, it is clear that simply planning or simply pursuing innovation is insufficient; these two perspectives must be structured together, mutually reinforcing each other. Studies show that innovation is not a process that can be left to chance or reduced to mere "creative ideas"; rather, it is a management area that gains meaning when integrated with strategy. It is understood that in businesses where the innovation strategy is not clearly defined, the organizational structure is not arranged to support this strategy, and resource allocation is not made accordingly, well-intentioned innovation efforts do not yield the desired results. Conversely, it can be said that businesses that clarify their innovation strategy, establish a flexible and learning-oriented organizational structure, and take ownership of this process at the top management level significantly increase their innovation performance and competitiveness. From the perspective of SMEs, the situation becomes even more critical. Despite being one of the pillars of the economy, these businesses operate with limited resources, making it essential for them to develop both strategic thinking and innovation skills to survive and grow. Findings show that increased awareness of strategic management in SMEs positively impacts their perception and application of innovation, indicating a bidirectional relationship between the two areas. Therefore, it is crucial for SMEs to clarify their medium- and long-term goals without getting lost in the pressure of daily operations; and to create a realistic yet innovative roadmap to achieve these goals. At the organizational level, several critical links complete the picture: strategic leadership, human resources management, organizational structure, culture, and technological competence. Strategic leadership requires an approach that can read the opportunities and risks in the environment, transform this reading into a clear vision, and unite employees around this vision. Human resources stands out as the party that selects, develops, and retains human capital that will carry this vision and is open to learning and innovation. Organizational structure and culture require an environment where innovative ideas can emerge and be discussed, where mistakes are not punished, and where trial and error are seen as a natural part of the learning process. Technological competence, on the other hand, represents the infrastructure that enables all these efforts to be supported by tangible tools. The weakness of any of these links significantly limits the potential of the strategic management-innovation relationship. Generally speaking, the strategic innovation approach offers a broader framework that goes beyond the traditional "simply renewing the product" mentality, requiring a holistic approach that considers the business model, value proposition, market positioning, and organizational structure together. The ability of businesses to transform themselves from actors merely adapting to existing competitive conditions into actors actively transforming these conditions is closely related to the extent to which this approach is internalized. Therefore, whether in large-scale enterprises or SMEs, establishing a management approach that explicitly includes the innovation dimension in strategic planning processes and places innovation projects at the center of the strategic agenda seems inevitable for organizations that want to survive and differentiate themselves in the coming period. In conclusion, this study demonstrates that strategic management and innovation should not be viewed as two separate, juxtaposed concepts, but rather as two fundamental management areas that complement each other and only gain meaning when considered together. The key to long-term success lies not in establishing a purely theoretical connection between these two areas, but in achieving holistic alignment that extends from goals and organizational structure to leadership style, human

resource policies, and technology choices. Businesses that achieve this alignment are more likely to adapt more quickly to changing competitive conditions, identify new opportunities more readily, and transform innovation into a sustainable competitive advantage.

References

1. Abraham, J.L., & Knight, D.J. (2001).Strategic innovation. Strategy and Leadership. 29(1), 21-27.
2. Aktan, C.C. (2008), Stratejik Yönetim ve Stratejik Planlama, Çimento İşveren Dergisi, 22(4), 4-21.
3. Aslan, İ. (2019). İşletme yönetiminde stratejik rekabet üstünlüğünün sağlanmasında; bir aracı olarak inovasyon stratejilerinin önemi. International Journal of Social and Humanities Sciences Research (JSHSR), 6(32), 9-21.
4. Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.
5. Barutçugil, İ. (2014). Liderlik (1. Basım). İstanbul: Kariyer Yayınları.
6. Bingöl, D. (2014). İnsan Kaynakları Yönetimi, Beta.
7. Bircan, İ. (2003); Kamuda Stratejik Yönetim ve AB Politikaları: Kamu Yönetiminde Kalite, 3. Ulusal Kongresi Bildirileri, TODAİE Yayın No: 319, Ankara: TODAİE Yayınları.
8. Bouckenooghe, D., Zafar, A., Raja, U. (2015). How Ethical Leadership Shapes Employees' Job Performance: The Mediating Roles of Goal Congruence and Psychological Capital, J Bus Ethics, 129: 251–264.
9. Brown, M. E., Treviño, L. K., Harrison, D. A. (2005). Ethical leadership: a social learning perspective for construct development and testing. Organizational Behavior and Human Decision Processes, 97 (2): 117-134.
10. Cormıcan, K. & O'sullġvan, D. (2004). Auditing Best Practice for Effective Product Innovation Management, Technovation.
11. Çetinkaya, F. F. ve Gülbahar, O. (2019). Stratejik yönetim ve inovasyon ilişkisi: KOBİ'ler üzerine bir araştırma. Ahi Evran Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 5(2), 349-367.
12. Damanpour, Fariborz (1991); "Organizational İnnovation: A Meta Analysis Of Effects Of Determinants And Moderators", Academy of Management Journal, Vol. 34, 555-90.
13. Dhar,R. L. (2016). Ethical leadership and its impact on service innovative behavior: The role of LMX and job autonomy, 57, 139-148.
14. Diken, A., Öge, S., Aslan, Ş., Aktan C. C. (2006); Geleceği Kazanmanın Yolu: Stratejik Yönetim, 14. Ulusal Yönetim ve Organizasyon Kongresi Bildiriler Kitabı, Erzurum.
15. Drejer, A. (2006). Strategic innovation: A new perspective on strategic management. Handbook of Business Strategy, 7(1), 143-147.
16. Drucker, P. (1985). The discipline of innovation. Harward Business Rewiew,1-9.
17. Elenkov, D.S., Judge, W. ve Wright, P. (2005). Strategic Leadership and Executive İnnovation İnfluence: An İnternational Multi-Cluster Comparative Study. StrategicManagement Journal, (26), 665–682.
18. European Commission (1995). Green paper on innovation. Erişim Tarihi: 05.12.2025, http://europa.eu/documents/comm/green_papers/pdf/com95_688_en.pdf.
19. Finkelstein, S. ve Hambrick, D. C. (2009). Strategic Leadership: Theory and Research on Executives, Top Management Teams and Boards. Oxford University Press Finalist, Academy of Management.
20. Govindarajan, V., & Trimble, C. (2004). Strategic innovation and the science of learning. MIT Sloan Management Review, 45(2), 67-75.
21. Hamel, G. (1998). Strategy innovation and the quest for value. Sloan Management Review, 39(2), 7-14.
22. Hancıoğlu, Y., & Yeşilaydın, G. (2016). Stratejik yönetimde yeni bir rekabet yaklaşimi: Stratejik inovasyon. Uluslararası Yönetim İktisat ve İşletme Dergisi, 12(29), 105-124.
23. Kalay, F., Tuncer, C. O., Kızıldere, C., & Kalay, H. A. (2016). Stratejik inovasyon yönetimi uygulamalarının firma inovasyon performansı üzerindeki etkileri. Bilgi Ekonomisi ve Yönetimi Dergisi, 10(2).
24. Kılıç, C. (2023). Stratejik yönetim ve inovasyon. İçinde V. Batdı & S. Ayaz (Ed.), İnovasyon yönetimi ve inovatif metaverse devrimi (ss. 69–90). Anı Yayıncılık.
25. Kim, T. T., Karatepe, O. M., Lee, G. (2017). Psychological contract breach and service innovation behavior: psychological capital as a mediator, Serv Bus, https://doi.org/10.1007/s11628-017-0347-4.
26. Markides, C. (1997). Strategic innovation. Sloan Management Review, Spring, 9-23.
27. Morris, L. (2013). Three dimensions of innovation. International Management Review, 9(2), 5-10.
28. OECD ve Eurostat (2005). Yenilik Verilerinin Toplanması ve Yorumlanması İçin İlkeler (3.Basım), TÜBİTAK.
29. Özgür Güler, E., & Kanber, S. (2011). İnovasyon aktivitelerinin inovasyon performansı üzerine etkileri: İmalat sanayii uygulaması. Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 20(1), 61-76.
30. Özsungur, F. (2017). Hizmet inovasyonu odaklı stratejik insan kaynakları yönetimi. International Journal of Entrepreneurship and Management Inquiries, 1(1), 8-18.
31. Papadakis, V. ve Bourantas, D. (1998). The Chief Executive Officer As Corporate Champion of Technological İnnovation: An Empirical İnvestigation. Technology Analysis and Strategic Management, 10 (1), 89–110.
32. Rogers, Everett,M. (1995); Diffusion of Innovation, 4th.ed., N.Y.: The Free Press.
33. Rowe, W.G. (2001). Creating Wealth İn Organisations: The Role of Strategic Leadership. Academy of Management Executive, 15 (1), 81–94.
34. Satı, Z. E., & Işık, Ö. G. D. Ö. (2011). İnovasyon ve stratejik yönetim sinerjisi: Stratejik inovasyon. Sosyal Bilimler Dergisi, 9(2), 538-559.

35. Sattler, M. (2011). Excellence in Innovation Management: A Meta-Analytic Rewiev on the Predictors of Innovation Performance**.** (1. Basım). Germany: Gabler Verlag.

36. Schlegelmilch, B. B., Diamantopoulas, A., & Kreuz, P. (2003).Strategic innovation: The construct, its drivers and its strategic outcomes. Journal of Strategic Marketing, 11, 117-132.

37. Sosik, J.J., Berson, Y., Jung, I. D., ve Jaussi, K.S. (2005). The Strategic Leadership of Top Executives İn High-Tech Organisations. Organisational Dynamics, 34 (1), 47–61.

38. Tankişi, B. (2018). Stratejik liderlik ile inovasyon yönetimi arasındaki ilişki: Otomotiv bayileri üzerine nitel bir araştırma. Yüksek Lisans Tezi Düzce Üniversitesi Sosyal Bilimler Enstitüsü Toplam Kalite Yönetimi Ana Bilim Dalı.

39. Trott, Paul (1998); "Innovation Management & New Product Development" Financial Times Pitman Publishing.

40. Uzkurt, C. (2010). İnovasyon Yönetimi: İnovasyon Nedir, Nasıl Yapılır ve Nasıl Pazarlanır? Ankara Sanayi Odası Yayını , Ankara.

41. Ünal, A. ve Kılınç, İ. (2016). İnovasyon yönetimi. (Editör: Kahraman Çatı). Girişimcilik ve İnovasyon Yönetimi. Ankara: Nobel Akademik Yayıncılık, 99-134.

42. Yalçın, B. ve Ay, C. (2007). Bilgi Toplumunda Örgütsel Dönüşüm Açısından Stratejik Mimari Boyutunda Stratejik Liderlik Analizi, (12. Bölüm). Toplam Kalite ve Stratejik Yönetimde Yeni Eğilimler (1. Basım). Ankara: Gazi Kitapevi.

TIKTOK'S IMPACT ON ONLINE SOCIAL BEHAVIOR IN THE US, UK, PAKISTAN, AND INDONESIA

Delgerjargal Maamuu
PhD candidate at the School of Social Sciences and Humanities,
Mongolian National University of Education.
ORCID ID: 0009-0002-5420-2233
DOI: 10.5281/zenodo.19327374

ABSTRACT

The rapid rise of TikTok as a dominant social media platform has sparked widespread interest in its impact on online social behavior. With its unique blend of short-form video content, user-generated creativity, and highly personalized algorithm, TikTok has revolutionized the way people interact, consume content, and express themselves in the digital realm. By combing and summarizing relevant literature, this paper identifies six core factors that affect users social behaviors: platform ease of use, platform content appeal, self-improvement motivation, social circle construction, common cultural or interest factors, and individual curiosity and interest orientation. In order to further explore the impact of these factors on the user group's stickiness on social platforms, this paper conducts a questionnaire survey on TikTok users in the United States, United Kingdom, Pakistan, and Indonesia to collect data, and uses SPSS statistical software for quantitative analysis. The results show that the ease of use of the platform, the realization of self-improvement, and the common cultural or interest factors all have a significant and positive promoting effect on the enhancement of users social stickiness, users from different countries do not show significant differences in social stickiness. Based on the above research, this paper puts forward relevant optimization suggestions from the three dimensions of constructing localization, promoting social interaction and strengthening self-promotion.

Keywords: TikTok; Network social behavior; Short videos.

Introduction

TikTok, as a rapidly ascending social media platform, has profoundly influenced online social behaviors, as evidenced by a multitude of research studies. Researchers have delved into various facets of TikTok's impact, shedding light on its effects on body image, educational practices, consumer behavior, and mental health, among others.

Several scholars have examined TikTok's influence on body satisfaction and image, particularly among younger generations. Several scholars conducted a mixed-methods study in Indonesia, revealing that TikTok significantly impacts body satisfaction among Generation Z. They found that exposure to idealized body images on the platform contributed to body dissatisfaction and disordered eating behaviors among young people (Ariana et al., 2024). Similarly, Several scholars investigated the direct and indirect relations between TikTok use and body dissatisfaction, concluding that frequent use was associated with heightened body dissatisfaction, especially among young women (Danielle et al., 2022). These findings underscore the platform's role in shaping body image perceptions and highlight the need for interventions to mitigate potential negative effects. In the realm of education, TikTok has emerged as a novel tool for learning and engagement. Several scholars explored how educators use TikTok, finding that teachers primarily use the platform for fun and personal expression but also recognize its potential for educational purposes. The authors suggested that TikTok could be harnessed to enhance student engagement and create a more interactive learning environment (Carpenter et al., 2024). Several scholars further extended this notion by developing an extended hedonic motivation adoption model for TikTok in higher education, emphasizing the platform's potential to motivate students through enjoyment and social interaction (Xinjie & Zhonggen, 2023). TikTok's impact on consumer behavior and e-commerce has also been a focal point of research. Some scholars conducted a survey study in China, examining trust in social media brands and perceived media values. Their findings revealed that trust in TikTok influencers significantly influenced consumers' purchasing intentions, highlighting the platform's role in shaping consumer behavior and brand loyalty (Mingmin et al., 2022). Additionally, Some scholars investigated the power of barrages (real-time comments) in boosting e-commerce sales through live streaming on TikTok. They found that barrages enhanced user engagement and purchase intentions, demonstrating the platform's efficacy in driving online sales (Zhao et al., 2024). The platform's role in social protest and political engagement has also garnered attention. Walsh examined TikTok's role as a site of social protest in Iran's Gen-Z uprising, noting that the platform facilitated the rapid dissemination of information and mobilization of young protesters. The author argued that TikTok's algorithm and user-generated content contributed to the platform's effectiveness as a tool for social and political change (Walsh, 2024).

However, TikTok's influence is not without concerns. Researchers have raised issues regarding the quality and accuracy of information on the platform. Several scholars analyzed oral diabetes medication videos on Douyin (the Chinese version of TikTok) and found that a significant portion of the content lacked scientific accuracy and credibility. The authors emphasized the need for stricter regulation and fact-checking mechanisms to ensure the dissemination of accurate health information (Zhang et al., 2024). Similarly, Several scholars conducted a cross-sectional analysis of chemical peel videos on TikTok, finding that nonphy-

sician-created content often omitted crucial risk information, potentially misleading viewers (Bhupalam et al., 2024). Mental health and well-being have also been areas of concern. Some scholars conducted a systematic review of the impact of TikTok on adolescent mental health, finding mixed results. While some studies suggested that TikTok could be a source of support and connection for adolescents, others highlighted the platform's potential to exacerbate anxiety, depression, and body image issues (Conte et al., 2024). These findings underscore the need for further research to understand the complex relationship between TikTok use and mental health outcomes. Furthermore, TikTok's privacy policies and data protection practices have been scrutinized. Some scholars assessed the platform's privacy policies and app settings in the U.S. and Europe, finding significant differences in user data protection measures. The authors argued that a more standardized and user-centered approach to data protection is necessary to ensure the safety and privacy of TikTok users (Kim & Bratt, 2024).In addition to these areas of focus, TikTok has also been studied in the context of specific health conditions and social issues. For example, Some scholars analyzed popular skin-of-color dermatology hashtags on TikTok, finding that the platform could be a valuable tool for disseminating dermatological information to underserved communities (Kang et al., 2024). Similarly, Some scholars examined the #Spoonietok community on TikTok, highlighting the platform's potential to support individuals with chronic illnesses through storytelling and information sharing (Lundy, 2024). In conclusion, TikTok has emerged as a multifaceted platform with profound impacts on network social behaviors. Its influence extends across various domains, including body image, education, consumer behavior, political engagement, mental health, and information dissemination. While the platform presents numerous opportunities for connection, learning, and expression, it also poses challenges related to information quality, privacy, and mental health. As TikTok continues to evolve, researchers and policymakers must grapple with these complexities to ensure that the platform's potential is harnessed for positive impact while mitigating potential risks. The insights from the aforementioned studies provide a comprehensive understanding of TikTok's multifarious effects and serve as a foundation for future research and intervention efforts.

1.Study design and operation

This paper systematically collected relevant data by developing a scale of TikTok's influence on network social behavior, and carrying out questionnaire design and sample collection. In order to dig deeper into the information behind the data, the factor analysis method is adopted to conduct scientific analysis of the collected data, so as to obtain accurate research results and verify the hypothesis put forward in the previous stage. The influence process of TikTok on online social behavior is shown in Figure 1.1.

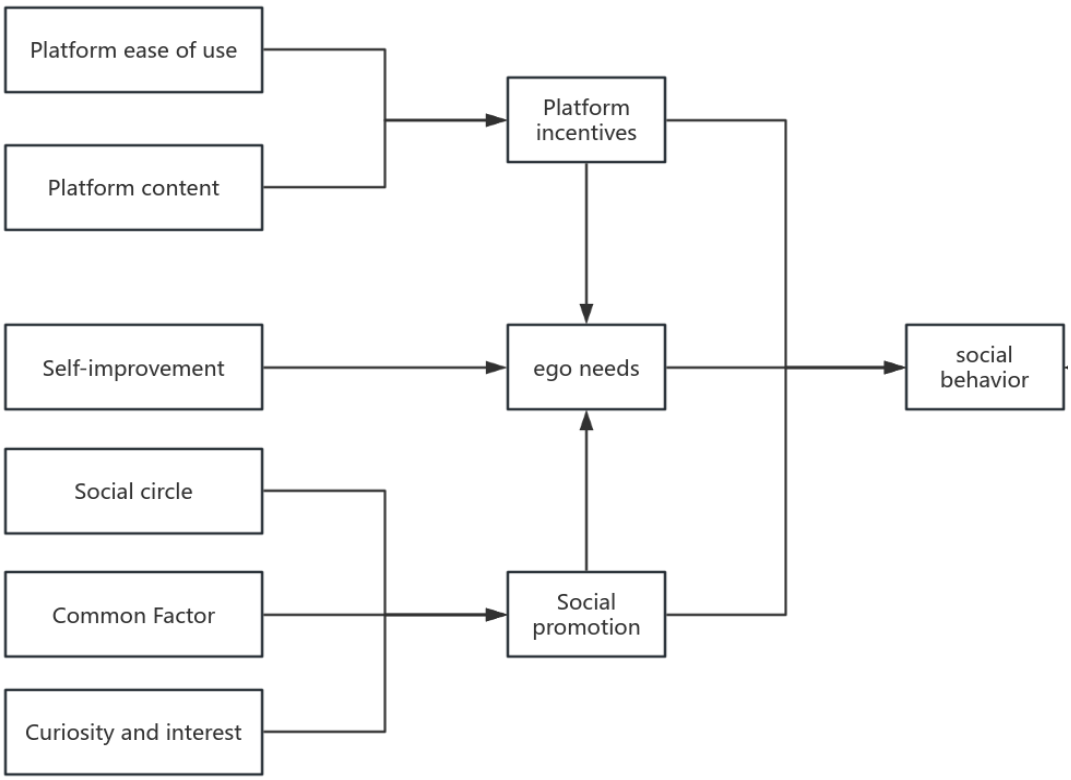


Figure 1.1 Process Diagram of TikTok's Influence on Online Social Behavior

1.1 Research design

1.1.1 Research hypothesis

Several scholars alluded to the platform's ease of use in their study exploring how educators use TikTok. They point out that educators are attracted by TikTok's fun and convenience, which implies that the platform is designed to pay attention to user experience, making it easy for even non-professional users to use it(Carpenter, 2024). Some scholars revealed the strong appeal of the platform's content through their analysis of dermatology-related content on TikTok. They found that popular hashtags and short videos about skin health were able to quickly attract a lot of attention, indicating TikTok's high appeal for content creation and distribution(Kang, 2024). However, A few scholars proposed an extended hedonic motivation adoption model to explain the use of TikTok by students in higher education. They found that students use TikTok not only for entertainment, but also for self-improvement and learning motivation(Xinjie D and Zhonggen Y, 2023). Some researchers examined how viral videos on TikTok affect offline relationships, finding that interactions and shared interests on the platform help build tight social circles. This shows that TikTok is not only a content sharing platform, but also a social tool, which can closely connect users through common cultural and interest factors, and form a stable social circle(Mendelson, 2024). Some researchers conducted an analysis of Tourette's disease content on TikTok and found that videos on the platform can reflect and shape public perceptions of the disorder. This demonstrates TikTok's important role in spreading shared culture and interests, not only by bringing together users with similar interests, but also by promoting the spread and exchange of culture through content creation and sharing (Thepmankorn et al., 2024). Several scholars conducted a study on social media brand trust in China and found that users choice and use of social media platforms is influenced by their personal interests and curiosity. Although the study did not directly focus on TikTok, it can be inferred that on platforms like TikTok, users personal curiosity and interest orientation are equally important factors in their choice of content to follow and engagement (Mingmin Z et al., 2022). Several researchers, in studying the social protests of Gen Z in Iran, pointed out that TikTok as a venue for social protests shows its strong social stickiness. Users not only share information and express opinions on the platform, but also form a strong sense of belonging through interaction and community building (Walsh, 2024). Based on the above research, this paper proposes the following hypothesis.

Table 1.1

List of research hypotheses

No.	Research hypothesis
A-1	The factors influencing the ease of use of the platform have a significant positive impact on the social stickiness of the social behaviors of TikTok user groups
A-2	The influence factors of platform content have a significant positive impact on the social stickiness of TikTok user groups social behaviors
A-3	Self-promotion influencing factors have a significant positive impact on the social stickiness of TikTok user groups in social behaviors
A-4	Social circle influence factors have a significant positive impact on the social stickiness of TikTok user groups in social behaviors
A-5	Common factors influencing factors have a significant positive impact on the social stickiness of TikTok user groups in conducting social behaviors
A-6	The influence factors of curiosity and interest have a significant positive impact on the social stickiness of TikTok user groups in social behaviors

1.1.2 Selection and determination of research variables

In this paper, the usability of the platform, platform content, self-improvement, social circle, common factors, curiosity and interest are selected as the variables of influencing factors, while the social behavior variables are selected from the issues and contents studied in this paper. The specific variables and explanations are shown in Table 1.2.

Table 1.2

Questionnaire survey scale

Categories of Variables	Variable name	Variable explanation	Sources
Influencing Factors Class	Platform ease of use	Social interaction can be easily achieved by using Tiktok's tag-collection function, fragmented time-saving viewing and interaction, and jumping to the TikTok platform through external promotion channels.	(Carpenter ,2024)
	Platform content	High-quality short video content, positive bloggers, let users feel its charm in TikTok, and actively interact with bloggers.	(Kang ,2024)
	Self-improvement	Users themselves will obtain information about society, life, entertainment and other aspects through TikTok to keep themselves and the society smooth. At the same time, they will also search for the knowledge and skills they need on TikTok to improve themselves, and regard TikTok platform as a platform for self-presentation and social communication through interactive display.	(Xinjie D ,2023)
	Social circle	Users use TikTok to make new friends and maintain existing interpersonal relationships, and obtain social recognition and find like-minded groups through the platform.	(Mendelson ,2024)
	Common Factor	Videos on TikTok resonate with groups of users and are shared in order to make others feel the same empathy.	(Thepmankorn ,2024)
	Curiosity and interest	I like and comment on videos that cater to my own interests and hobbies. At the same time, I interact and socialize on TikTok based on curiosity and voyeurism in order to better understand and feel the social life of others.	(Mingmin Z ,2022)
Social Behavior Class	Social Stickiness	The user's social loyalty on the TikTok platform, as well as the degree of dependence and continuous social interaction formed by having a good social experience.	(Walsh ,2024)

In this paper, six variables of influencing factors are taken as the independent variables of the study, and social viscosity of social behavior is taken as the dependent variable, so as to facilitate subsequent exploration of the specific relationship between independent variables and social viscosity of dependent variables.

1.2 Research operations

1.2.1 Questionnaire design

The questionnaire design includes three parts: basic information, usage and influencing factors. Usage includes usage frequency, usage behavior, usage preference and social stickiness. The influencing factors include platform ease of use, platform content, self-improvement, social network, common factors, curiosity and interest; Basic information, including gender, age, education background, etc., was used to complete the questionnaire design.

Table 1.3

Variable indicator operationalization definition

Variable Types	Variable indicator	Statement expression
Dependent variable	Social stickiness	1. Scrolling through TikTok every day has become a part of my daily routine 2. I will continue to use TikTok for social interaction (like/comment/private chat/repost and share)
Independent Variable	Platform ease of use	1. I think the ability to tag and save videos with likes on TikTok is very practical 2. The advantages of short and fast TikTok are very consistent with my daily habits 3. When I often see an interesting blogger or video on external media such as Weibo, I will click to jump and search for more related content on TikTok for proper interaction 4. I like to use TikTok to record and share my life 5. I like to shoot and share all kinds of magic facial effects of TikTok
	Platform content	1. I will take the initiative to like/comment/share high-quality video (operation mirror, special effects, etc.) 2. When I see positive videos of positive energy/traditional culture/official media, I will actively like/comment/share
	Self Improvement	1. I get a lot of information (current affairs, popular science, etc.) on TikTok, and I will actively interact with those who agree with me 2. I can learn a lot of knowledge/skills from TikTok 3. I like to show myself on TikTok, for example, I can share and show my good skills or field knowledge
	Social circle	1. When socializing on TikTok, I often feel that I agree with certain comments or that my comments/videos are approved by others 2. I feel happy and satisfied when my videos receive likes/comments/private chats 3. I make new friends by interacting with strangers on TikTok 4. I interact with acquaintances on TikTok based on videos (private chat, @, etc.) 5. I can see or know many interested/like-minded people on TikTok, and I am willing to have social interaction with them
	Common Factors	1. When I see an interesting video and think my friend will be interested, I retweet or @him 2. If a video impresses me, I like/comment on the interaction 3. When I meet happy videos, I like to share them with my friends and want to share the happiness
	Curiosity and interest	1. I actively interact (like/comment/chat) with content/bloggers that are in line with my interests 2. I like to watch other people's (strangers/friends) life videos on TikTok, so that I can understand their life status

1.2.2 Sample survey

After completing the questionnaire design, this paper started to conduct a formal questionnaire survey, which was distributed online to ensure the randomness of the objects to be filled in. A total of 205 questionnaires were received.

Table 1.4

Summary of sample processing

	N	%
Valid	205	100
a ruled out	0	0
Total	205	100

1.3 Basic analysis of the research questionnaire

1.3.1 Descriptive analysis of survey samples

Through the collation of samples, data statistics and diversified analysis, combined with the research topic of this paper, the survey results will be displayed and analyzed in the form of charts, and the results are as follows:

Table 1.5

Demographic information

Information	Project	Sample size	Frequency	Proportion
gender	male	205	114	55.61%
	female	205	91	44.39%
region	First tier regions	205	50	24.39%
	Second tier regions	205	123	60%
	Other regions	205	32	15.61%
Educational level	High school or below	205	21	10.24%
	Associate Degree	205	38	18.54%
	Bachelor's Degree	205	111	54.15%
	Master's degree or above	205	35	17.07%
Occupational distribution	student	205	73	35.61%
	Professional personnel (such as doctors/lawyers, etc.)	205	24	11.71%
	Service industry employees	205	36	17.56%
	Enterprise employees	205	35	17.07%
	Businessman/Employer	205	6	2.93%
	Freelancing and others	205	31	15.12%

As we can see The sample consists of 205 individuals, with a near-even split between males and females. Males make up 55.61% of the sample with 114 individuals, while females account for 44.39% with 91 individuals. Geographically, the sample is categorized into three regions. First tier regions have the smallest representation with 24.39% (50 individuals), followed by other regions with 15.61% (32 individuals). Second tier regions have the highest frequency with 60% of the sample (123 individuals). In terms of educational attainment, the sample is fairly diverse. The largest group is those with a Bachelor's Degree, comprising 54.15% (111 individuals). This is followed by individuals with an Associate Degree at 18.54% (38 individuals), high school or below at 10.24% (21 individuals), and the smallest group being those with a Master's degree or above at 17.07% (35 individuals).

The occupational distribution within the sample shows a significant portion of students at 35.61% (73 individuals). This is followed by enterprise employees and service industry employees, both at 17.07% and 17.56% respectively (35 and 36 individuals). Professional personnel such as doctors and lawyers make up 11.71% (24 individuals), and businessmen/employers represent the smallest group at 2.93% (6 individuals). Freelancing and other occupations account for 15.12% of the sample (31 individuals).

The sample is relatively balanced in terms of gender but skewed towards individuals from second tier regions. Educational levels vary, with a significant majority holding a Bachelor's Degree. The occupational distribution indicates a youthful sample with a large student population, which is consistent with the high proportion of individuals in entry-level positions such as service industry employees and a smaller percentage of professionals and business owners. This information can be valuable for understanding the background of the sample and for making informed decisions based on the demographic characteristics of the sample population.

Table 1.6

Duration of use

Duration of use	Sample size	frequency	Percentage
Half an hour or less	205	58	28.29%
Half an hour -1 hour	205	63	30.73%
1 hour -3 hours	205	61	29.76%
More than 3 hours	205	23	11.22%

The majority of the sample (88.07%) spends up to three hours on the activity or platform, with the most common duration being between half an hour to one hour. This could suggest that while the platform or activity is popular, it is not overly time-consuming for most users. However, a small but notable percentage of users spend more than three hours, which might indicate a more intense level of engagement or potential overuse. This information is crucial for understanding user behavior, planning content strategies, and considering the impact of the platform or activity on users' daily lives.

1.3.2 Reliability and validity and factor analysis

1.3.2.1 Reliability analysis

Klonbach alpha coefficient is used to detect and analyze the reliability of the questionnaire. Cronbach a coefficient must be greater than 0.7 to indicate that the reliability is barely acceptable. If Cronbach a coefficient is greater than 0.9, it will prove that the reliability of the questionnaire is excellent, and relevant data research can be carried out in the next step.

Table 1.8

Reliability statistics of the questionnaire

Names of factors	Dimensions	Number of items	Dimension Cronbach's a value	Variable Cronbach's a value
Influencing factors of network social behavior	Platform ease of use	5	0.87	0.808
	Platform content	2	0.819	
	Self-improvement	3	0.849	
	Social network	5	0.887	
	Common factor	3	0.817	
	Curiosity and interest	2	0.831	

As shown in Table 1.8, Cronbach's a coefficient is 0.808 (coefficient is the standard greater than 0.7), and Cronbach's a coefficient of the six influential factors is also greater than 0.8, indicating that the reliability quality of the questionnaire is high and the research can be continued.

1.3.2.2 Validity analysis

The validity of the questionnaire is the key index to measure its measurement accuracy. The higher the validity, the more the measurement results can truly and accurately reflect the core features of the research content. In this paper, exploratory factor analysis (EFA) was used for evaluation, and the validity was analyzed by KMO value and Bartley sphericity test. When the KMO value exceeds 0.7, the validity of the questionnaire data can be considered to have reached a basically acceptable level. When the KMO value is above 0.9, it indicates that the sample data of the questionnaire is very suitable for factor analysis.

Table 1.9

KMO values of the questionnaire and Bartley sphericity test

Sample sufficient degrees of Kaiser-Meyer-Olkin	Metrics	0.813
Bartlett's sphericity test	Approximate Chi-square	4476
	df	231
	p value	0.000

As shown in Table 1.9, the KMO value of the questionnaire is 0.813 (greater than 0.7), indicating that the questionnaire has good validity. Meanwhile, the P-value (significance) of the Bartley sphericity test is 0.000, less than 0.01, indicating that the validity test has good reliability and can be carried out for further research.

1.3.2.3 Factor analysis

Factor analysis is used to categorize many variables scientifically and systematically, explore the complex relationship between variables, and reduce the original complex variables to a few representative common factors through a fine analysis process. These common factors can not only highly summarize the core information of the original variable, but also clearly reveal the internal structural relationship between the variables.

Table 1.10

Factor analysis

item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
DJ1	0.799	0.031	0.157	0.133	0.042	0.031
DJ2	0.774	0.036	0.113	0.207	-0.019	-0.03
DJ3	0.787	-0.055	0.162	0.162	0.019	0.017
DJ4	0.797	0.013	0.163	0.13	0	-0.013
DJ5	0.787	-0.009	0.16	0.153	-0.038	-0.003
DJ6	-0.012	0.055	-0.014	0.002	-0.041	0.89
DJ7	0.014	0.037	0.005	-0.011	0.023	0.892
DJ8	0.26	0.087	0.795	0.208	0.028	-0.005
DJ9	0.251	0.071	0.794	0.211	0.019	-0.002
DJ10	0.207	0.069	0.783	0.257	-0.009	-0.007
DJ11	-0.015	0.736	0.059	0	-0.058	0.031
DJ12	-0.026	0.742	0.035	-0.036	0.021	0.016
DJ13	0.02	0.745	0.078	0.045	0	-0.043
DJ14	-0.006	0.681	-0.057	0.107	0.019	0.062
DJ15	0.047	0.734	0.087	-0.024	-0.009	0.036
DJ16	0.274	0.051	0.183	0.76	-0.026	0.019
DJ17	0.226	0.015	0.279	0.758	0.043	-0.009
DJ18	0.235	0.027	0.212	0.785	-0.014	-0.023
DJ19	0.031	-0.038	0.063	-0.01	0.894	-0.033
DJ20	-0.029	0.015	-0.033	0.01	0.896	0.015

Note: Cumulative variance contribution rate =71.82%

As shown in Table 1.10, the explanation rate of cumulative variance after rotation is 71.82%, indicating strong factor fitting effect and explanation ability, and reflecting the key influencing factors of the original variables. At the same time, the common degree values corresponding to the research items (titles) in this study are all higher than 0.4, which indicates that there is a relatively strong correlation between the research items and the factors, and the factors can also effectively extract relevant information.

2.Empirical analysis of TikTok's impact on online social behavior in the United States, the United Kingdom, Pakistan and Indonesia

2.1 Correlation analysis of influencing factors of online social behavior

Correlation test is to test the correlation degree of two variables, that is, to analyze the correlation coefficient between two variables of equal importance. Spearman's correlation coefficient is used in this paper to analyze the correlation between the six influential factors of TikTok users network social behavior and social stickiness.

Table 2.1

Correlation between influencing factors and social stickiness

Independent Variable	Correlation coefficient (social stickiness)
Platform ease of use	0.506 * *
Platform content	-0.028
Self-improvement	0.515 * *
Social networking circles	0.077
Common factors	0.554 * *
Curiosity and interest	0.022

As Table 2.1 shows, platform ease of use, self-improvement, and common factors all show a positive correlation with strong social stickiness. The correlation coefficient of platform ease-of-use is 0.506, $p<0.01$, indicating that the ease of operation of the platform has a significant impact on enhancing users social stickiness. The correlation coefficient of self-improvement is 0.515, $p<0.01$, which means that the stronger the user's self-improvement experience on the platform, the higher their social stickiness will be accordingly. The correlation coefficient of common factors was as high as 0.554**, $p<0.01$, which highlights the important role of shared interests, values or goals in promoting strong connections among users.

In contrast, platform content and curiosity and interest were weakly correlated with social engagement. The correlation coefficient of platform content is -0.028, indicating that the richness or quality of platform content has no obvious direct influence on users social stickiness; The correlation coefficient of curiosity and interest is only 0.022, which also shows that these two factors play a limited role in directly promoting users' social stickiness. The correlation coefficient of the social interpersonal circle is 0.077, which is positive but the correlation degree is low, indicating that the social interpersonal circle itself may not be the dominant factor in determining social stickiness, but it may have a certain influence on social stickiness under the joint action of other factors.

2.2 Difference analysis between countries and social stickiness

Table 2.2

Difference analysis between country and social stickiness

Name of Variable	Variable value	Sample size	Average	Standard deviation	Variance test
Social stickiness	America	205	3.043	0.956	F = 0.085, P = 0.918
	Britain	205	3.059	0.89	
	Pakistan	205	3.051	0.957	
	Indonesia	205	3.001	0.938	

As shown in Table 2.2, ANOVA test was conducted according to the groups of the United States, the United Kingdom, Pakistan and Indonesia to explore the differences in social stickiness of users in different countries. The results show that F value is 0.085, P value is 0.918, and users from different countries do not show significant differences in social stickiness.

2.3 Analysis on the effect of influencing factors of network social behavior

Through correlation analysis, the degree of correlation between variables has been preliminarily verified. In order to further explore the effects of platform ease of use, self-improvement and common factors on social stickiness in the online social behaviors of TikTok users, linear regression analysis was used for quantitative demonstration. In the previous correlation analysis, it has been identified that only three key factors are highly correlated with social stickiness. Therefore, this linear regression sets social stickiness as the dependent variable and these three key factors as the independent variables in order to more precisely analyze their influence on social stickiness. At the same time, in order to improve the accuracy and reduce the error of the model, gender and education background were introduced as control variables, and a multiple linear regression model was constructed to further explore the significant impact of each influencing factor on social stickiness.

Table 2.3

Linear regression analysis of six influential factors

Variables	Nonstandardized coefficient (B)	t	p	VIF
Platform ease of use	0.295 * *	5.78	0.000 * *	1.55
Platform content	-0.027	-0.675	0.501	1.078
Self-improvement	0.257 * *	4.967	0.000 * *	1.72
Social networking circle	0.025	0.526	0.6	1.094
Common factors	0.361 * *	6.764	0.000 * *	1.728
Curiosity and interest	0.015	0.372	0.71	1.065
Gender (control variable)	-0.03	-0.253	0.8	1.104
Education (control variable)	0.012	0.17	0.864	1.062

As shown in Table 2.3, among the factors influencing the social stickiness of Tiktok users, platform ease of use, self-improvement and common factors all show significant positive effects. The non-standardized coefficient of platform ease-of-use is 0.295, which is highly statistically significant ($t=5.78$, $p<0.001$), indicating that the ease of operation of the platform plays an important role in improving users social stickiness. The non-standardization coefficient of self-improvement was 0.257, which was also highly significant ($t=4.967$, $p<0.001$), indicating that users' self-improvement experience on the platform was also a key factor in enhancing social stickiness; The common factor had the highest and statistically significant coefficient of 0.361 ($t=6.764$, $p<0.001$), underscoring the central role of shared interests or goals in bringing users closer together. In contrast, the effects of platform content, social network, curiosity and interest, and control variables gender and education on social engagement were relatively weak and mostly not statistically significant. In addition, the variance inflation factor (VIF) of each variable is less than 2, indicating that there is no serious multicollinearity problem in the model.

2.4 Hypothesis testing

Through correlation coefficient analysis and linear regression analysis, this article explores the relationship between six factors: platform usability, platform content, self-improvement, social circle, common factors, curiosity, and interest, and user social stickiness. Based on the above research, the hypotheses previously proposed were validated, and the validation results are as follows.

Table 2.4

Hypothesis Test Results

Research hypothesis	Inspection results
(A-1)The platform usability factors have a significant positive impact on the social viscosity of TikTok users social behavior	valid
(A-2)The platform content influencing factors have a significant positive impact on the social viscosity of TikTok users social behavior	not valid
(A-3)Self improvement influencing factors have a significant positive impact on the social viscosity of TikTok users social behavior	valid
(A-4)Social circle influencing factors have a significant positive impact on social viscosity of TikTok users social behavior	not valid
(A-5)Common factors have a significant positive impact on the social viscosity of TikTok users social behavior	valid
(A-6)The influence factors of curiosity and interest have a significant positive impact on the social viscosity of TikTok users social behavior	not valid

As shown in Table 2.4, the three influencing factors of platform usability, self-improvement, and common factors have a significant positive impact on the social stickiness of online social behavior, and the hypothesis is valid. The research hypotheses regarding other influencing factors are not valid.

3. Conclusions and discussion

3.1 Conclusion

By studying TikTok's impact on online social behavior in the United States, the United Kingdom, Pakistan and Indonesia, this paper reveals its unique social behavior characteristics and main influencing factors, further enriching the research on online social behavior in the new media environment. As a powerful medium, TikTok constructs a fragmented metaphorical world with its short, frequent and fast features, which has a profound impact on users social habits and ways of thinking. The main conclusions of this study are as follows:

Platform ease of use, self-improvement and common factors were identified as the main factors affecting online social behavior. As a limited extension of social behavior, platform ease-of-use lowers the threshold of user participation and promotes the widespread occurrence of social behavior through continuous iteration of functions and convenient social tools. The self-improvement factor reflects the initiative of the group in the social process. They display their self-image, learn knowledge and skills, and obtain information through the platform, so as to improve their personal value and meet their social needs. Common factors, as a bond connecting the emotions among users, build an intimate and amiable interpersonal network through empathy and shared happiness, and further enhance social stickiness. Through ANOVA test, the F-value was 0.089, and the P-value was 0.966. Users from the United States, the United Kingdom, Pakistan and Indonesia showed no significant difference in social stickiness. In the United States, users show a high interest in humorous videos, fashion and beauty tutorials, and other related content. American culture is diverse and emphasizes individual expression, and young people hope to showcase their unique style through these contents while obtaining fashion trend information. For example, some beauty bloggers share various makeup techniques and product recommendations on TikTok, attracting a large number of fans' attention.

In the UK, sports news, fashion trends, and creative video content are highly favored by users. The UK has a strong sports culture tradition and a high level of attention to sports news. At the same time, the fashion industry is well-developed, and users have a great demand for fashion related content. For example, fashionistas showcase the latest fashion trends on TikTok, sparking imitations and discussions among users. In Pakistan, traditional music and dance, as well as local cultural exhibitions, are more favored. Pakistan has a rich cultural heritage, and users showcase traditional music and dance on TikTok to promote local culture. In addition, some interesting life stories and talent performances can also attract a certain amount of user attention. In Indonesia, food preparation, travel guides, and music and dance content are the most popular. Indonesian cuisine is rich and diverse, and users can attract likes and comments from other users by sharing the process of food preparation. Travel guides are also very popular because Indonesia has beautiful natural scenery and unique cultural attractions. Meanwhile, music and dance are important components of Indonesian culture, and users showcase various exciting music and dance performances on the platform.

American users actively participate in various challenges and interactive activities on the platform, responding to challenges through creative videos and establishing connections with other users. They will also have lively discussions in the comment section, sharing their views and experiences. For example, some dance challenges are very popular in the United States, and users are uploading their own dance videos, liking and commenting on each other. British users are more inclined to engage in social interaction by sharing interesting life stories and participating in topic discussions. They will share their daily lives in a humorous way to resonate with other users. Meanwhile, for some popular topics, British users will actively express their opinions, creating a good interactive atmosphere.

Although Pakistan users are subject to network restrictions, they still interact with other users through likes, comments, and shares. They pay special attention to content related to local culture and express their love and support for it through interaction.

Indonesian users actively participate in commenting, liking, and sharing, interacting and communicating with other users. They will also establish deeper connections with other users through private messages and other means, sharing food making experiences, travel experiences, etc. In addition, Indonesian users will also participate in various challenge activities to showcase their talents and creativity.

Cultural factors are one of the important reasons for the differences in age distribution among different countries. In the United States, cultural diversity and an open attitude towards emerging things make it easier for young people to accept TikTok. At the same time, the education system in the United States also focuses on cultivating students' creativity and expression abilities, which is in line with the platform characteristics of TikTok. In the UK, traditional news media and education systems have led to a high demand for information among teenagers, and TikTok's personalized recommendation algorithm can meet their interests. In Pakistan, due to cultural traditions and social norms, older users may have resistance towards some content on TikTok. In Indonesia, with a large young population and high popularity of social media, TikTok has provided a favorable environment for its development.

Social environment is also an important factor affecting age distribution. In the United States and the United Kingdom, with well-developed network infrastructure and high popularity of smartphones, young people are more likely to access TikTok. In Pakistan, although the network infrastructure is relatively backward, the younger generation's thirst for emerging things still drives them to actively use TikTok. In Indonesia, the network infrastructure in urban areas is relatively complete, making it easier for young people to access TikTok, while the development in rural areas is relatively lagging, limiting TikTok's popularity in rural areas.

3.2 Discussion

3.2.1 Construction Localization

In the process of globalization of TikTok platform, the implementation of localization strategy is the key to win the hearts of users in all regions. In order to do this, TikTok needs to deeply integrate into the local history, cultural background and social characteristics to ensure that every piece of content can accurately touch users hearts and inspire their enthusiasm for social interaction. This requires the TikTok team not only to have the ability to communicate across cultures, but also to observe and analyze the psychological dynamics and behavior patterns of the user group in detail, just like anthropologists. By deeply understanding how local culture shapes the psychological structure of users, TikTok can more accurately grasp the deep logic and core characteristics of users social behaviors, so as to create content that conforms to local cultural characteristics and can touch users emotional resonance. Such a content strategy can not only significantly improve the local fit of the content, let users feel the warmth and intimacy of the platform, but also build an emotional bridge between users based on common cultural identity and enhance social stickiness. In the long run, TikTok can not only gain a firm foothold in the local market, but also establish a unique brand image in the hearts of users, laying a solid user base and market reputation for the subsequent in-depth expansion. Through this series of localization efforts, TikTok will truly realize the gorgeous turn from “outsider” to “localization expert”, so that every user can find a sense of belonging on the platform and enjoy the fun of social interaction.

3.2.2 Promote social interaction

In response to the frequent user feedback about the lack of tagging and favorites, the platform should quickly respond by adding a dedicated function area to optimize the user experience. This area should be designed to be both intuitive and easy to use, allowing users to easily flag video content that has sparked interest or resonance, and quickly track it back when needed, thus greatly reducing the time cost of follow-up searches. Such improvements not only greatly improve the convenience of user operation, so that users can enjoy the content at the same time, but also more smoothly participate in social interaction, and enhance the coherence and depth of social behavior, promote the multi-dimensional communication and sharing between users. In addition, in view of the “information cocoon” effect that may be brought about by intelligent algorithm recommendation, TikTok should show its open and inclusive platform attitude and introduce an innovative recommendation switch mechanism. This mechanism allows users to independently choose whether to accept personalized content recommendations according to their own wishes. In this way, users are no longer passive recipients of information, but become masters of their own information world. This kind of design breaks the one-sided indoctrination that may be brought by media technology and gives users more choice and autonomy, so as to better meet the diversified social needs of users. Through careful optimization in these two aspects, TikTok platform can not only more accurately meet the personalized preferences of users, but also build a more open, diverse and dynamic social ecology while broadening the breadth and depth of social interaction, so that every user can fly freely in this digital world and enjoy the infinite fun of social interaction.

3.2.3 Strengthen self-improvement

Focus first on providing rich and high-quality “knowledge” content. In this era of information explosion, users have an increasing demand for valuable and in-depth information. Following this trend, TikTok should carefully plan and launch knowledge content covering various fields such as cutting-edge science and technology, humanistic history and life encyclopedia, which not only meets users thirst for fresh information, but also helps them have more say in online and offline social occasions. Through the dissemination of such nutritious information, TikTok not only helps users broaden their horizons and broaden their knowledge, but also enhances their social influence and makes them more confident and calm in communication. At the same time, TikTok is also an excellent “stage” for users to show themselves and realize their self-worth. Here, users are not only enthusiastic audiences, enjoying wonderful performances from all over the world, but also bright stars on the stage, bravely

showing their talents and personalities, and accepting the scrutiny and feedback from others. This dual role transformation prompts users to constantly examine themselves in social interaction, gradually peel away from the external evaluation of “he and I”, and deeply explore and recognize the real “ID”. In this process, the user’s wisdom and insight can collide and blend, they learn how to break through the complicated illusion fog, bravely walk out of the shackles set by themselves, and eventually grow into the “Republic” wise people who can think independently, distinguish right from wrong, and pursue truth.

References

1. Ariana, H., Almuhtadi, I., & Natania, J. N. et al. (2024). Influence of TikTok on body satisfaction among Generation Z in Indonesia: Mixed methods approach. JMIR Human Factors, 11, e58371.

2. Chelsey, B., & Ioana, L. (2019). TikTok as a lens into teacher attrition: Perspectives from #teacherquittok. English Teaching: Journal of Practice & Critique, 23(3), 301-316.

3. Iddrisu, M., Alexander, P., & Kwami, S. A. et al. (2019). Social networking platform and tourism destination evangelism: Government regulatory responses. Tourism Critiques: Practice and Theory, 5(1), 138-152.

4. Carpenter, P. J., Morrison, A. S., & Shelton, C. C. et al. (2024). How and why educators use TikTok: Come for the fun, stay for the learning? Teaching and Teacher Education, 142, 104530.

5. Mendelson, A. E. (2019). Sensemaking and public intimacy on TikTok: How viral videos influence interpersonal relationships offline. New Media & Society, 26(12), 7081-7099.

6. Xinjie, D., & Zhonggen, Y. (2023). An extended hedonic motivation adoption model of TikTok in higher education. Education and Information Technologies, 28(10), 21-23.

7. A. J. H., Kevin, J. T., & Marika, T. (2023). TikTok, TikTok, the time is now: Future directions in social media and body image. Body Image, 44, 222-226.

8. Danielle, M. B., & M. D. S. (2022). TikTok use and body dissatisfaction: Examining direct, indirect, and moderated relations. Body Image, 43, 205-216.

9. Mingmin, Z., Ping, X., & Yinjiao, Y. (2022). Trust in social media brands and perceived media values: A survey study in China. *Computers in Human Behavior, 127.

10. K. M. M. (2021). How can Booktok on TikTok inform readers' advisory services for young people? *Library & Information Science Research, 43(2), 101091.

11. Liu, W., Zhao, X., & Zhan, M. et al. (2024). Streaming disasters on TikTok: Examining social mediated crisis communication, public engagement, and emotional responses during the 2023 Maui wildfire. Public Relations Review, 50(5), 102512.

12. Tiffany Queen expands influence as music artist and social media star, garnering millions of TikTok and Instagram views. (2024). M2 Presswire.

13. Kang, J., Szeto, D. M., & Suh, L. et al. (2024). Popular skin-of-color dermatology social media hashtags on TikTok from 2021 to 2022: The content analysis. JMIR Dermatology, 7, e50408.

14. Gansner, M. (2024). Can parents fall prey to "TikTok diagnoses?": Caregivers and social media misinformation. Journal of the American Academy of Child & Adolescent Psychiatry, 63(10S), S112-S113.

15. Thepmankorn, P., Asamoa, M. A., & Jarmon, R. E. (2024). How social media portrays Tourette's disorder: A TikTok analysis. Journal of the American Academy of Child & Adolescent Psychiatry, 63(10S), S303-S304.

16. Weigle, E. P., & Rizwan, B. (2024). Paging Doctor TikTok: Social media psychoeducation, misinformation, and contagion. Journal of the American Academy of Child & Adolescent Psychiatry, 63(10S), S120.

17. Chapalamadugu, M., Rodriguez, S., & Patrizio, P. (2024). TikTok fertility trends: A qualitative analysis of posts on social media. Fertility and Sterility, 122(4S), e135-e136.

18. Kamat, A. P., Cromack, C. S., & Walter, R. J. (2024). TikTok, cycle tracking, and tryingtoconceive: A video content analysis of at-home urinary hormone monitors on social media. Fertility and Sterility, 122(4S), e136-e137.

19. Ariana, H., Almuhtadi, I., & Natania, J. N. et al. (2024). Influence of TikTok on body satisfaction among Generation Z in Indonesia: Mixed methods approach. JMIR Human Factors, 11, e58371.

20. Walsh, T. (2024). TikTok as a site of social protest in Iran's Gen-Z uprising. *Discourse & Society, 35*(5), 625-650.

21. Zhang, B., Kalampakorn, S., & Powwattana, A. et al. (2024). Oral diabetes medication videos on TikTok: Analysis of information quality and user comment attitudes. JMIR Formative Research, 8, e57720.

22. Li, A., Xing, Q., & Zhang, Y. et al. (2024). Evaluation of the information quality related to osteoporosis on TikTok. BMC Public Health, 24(1), 2880.

23. Zhang, R., Zhang, Z., & Jie, H. et al. (2024). Analyzing dissemination, quality, and reliability of Chinese brain tumor-related short videos on TikTok and Bilibili: A cross-sectional study. Frontiers in Neurology, 15, 1404038.

24. Storfund partners with TikTok Shop. (2024). Manufacturing Close-Up.

25. Bhupalam, V., Awad, N., & Hetzel, J. (2024). Omission of risk undermines the value of content created by nonphysicians: A cross-sectional analysis of chemical peel videos on TikTok. JAAD International, 17, 124-125.

26. Zhao, J., Zhou, J., & Wu, P. et al. (2024). Boosting e-commerce sales with live streaming: The power of barrages. Electronic Commerce Research. Advance online publication.

27. Conte, G., Iorio, D. G., & Esposito, D. et al. (2024). Scrolling through adolescence: A systematic review of the impact of TikTok on adolescent mental health. European Child & Adolescent Psychiatry. Advance online publication.

28. Kim, H., & Bratt, S. (2024). Assessing privacy policies and app settings for user data protection: A data subject-centered framework analysis of TikTok in the

U.S. and Europe (2023–2024). Proceedings of the Association for Information Science and Technology, 61(1), 183-193.

29. Lundy, M. (2024). Welcome to spoonietok: Understanding and supporting disability expertise, storytelling abilities, and collective information practices on TikTok and beyond. Proceedings of the Association for Information Science and Technology, 1008-1010.

30. Duan, Y., Khoury, C., & Joh, U. et al. (2024). Comparing climate change content and comments across Instagram Reels, TikTok, and YouTube Shorts and long videos. Proceedings of the Association for Information Science and Technology, 61, 103-114.

TECHNICAL SCIENCES

FUZZY IF-THEN RULE BASED DECISION MAKING

Jabbarova K.,
Doctor of Philosophy, associate professor of Azerbaijan State Oil and Industry University
Jafarov N.
master's student of Azerbaijan State Oil and Industry University
DOI: 10.5281/zenodo.19327397

ABSTRACT

The decision-making process based on IF-THEN rules is a widely used technique for decision making. This technique is used in fuzzy logic systems. The knowledge about a particular problem is represented using logical rules. The rules used are of the form IF-THEN, i.e., if a particular condition is satisfied, then a particular action or result is performed. The conditions are represented by the IF part of the rule, while the action or result is represented by the THEN part. The rules used are normally represented by terms such as low, medium, or high. This makes the decision-making process easier. Once the values are provided to the decision-making process, the decision is made based on these rules. This technique is widely used for decision making.

Keywords: Knowledge Based Systems, IF-THEN rule, Expert Systems, Artificial Intelligence (AI), distance.

1. Introduction

Knowledge-based systems are often referred to as intelligent decision support systems. A Decision Support System (DSS) is a tool designed to help decision makers analyze and solve complex problems. Typically, a DSS supports the analysis of data while leaving the interpretation of results and the final decision-making process to the human user [1].

In contrast, knowledge-based systems and expert systems are developed with proactive reasoning capabilities. Under appropriate conditions, these systems can take on part of the interpretation and decision-making responsibilities that would otherwise belong solely to the user.

Artificial Intelligence (AI), an interdisciplinary area that combines computer science and cognitive psychology, initially focused on achieving general intelligence. Early research assumed that human intelligence was mainly based on a small set of domain-independent problem-solving strategies. However, later studies revealed that although these methods were useful, they were insufficient for solving complex real-world problems.

Researchers discovered that effective problem solving in such environments requires extensive domain-specific knowledge and the ability to process that knowledge in ways that resemble human reasoning rather than relying solely on traditional computational approaches. Consequently, systems have been developed to represent and model human expertise within a clearly defined domain. These systems provide intelligent assistance to professionals and are commonly known as knowledge-based systems or expert systems.

Knowledge-Based Systems [2]

Knowledge-Based Systems (KBS), often referred to as expert systems, utilize both domain-specific knowledge and general knowledge to solve problems. These systems apply heuristic approaches in addition to traditional algorithmic techniques. As a result, they are able to perform effectively within a particular problem domain, producing accurate and practical solutions within a reasonable time frame. Another important feature of knowledge-based systems is their ability to explain the reasoning and knowledge behind the solutions they generate.

An additional characteristic of KBS is their flexibility. The knowledge stored in the system can be modified, expanded, or reduced by updating the knowledge base without requiring major changes to the underlying program structure.

The design and development of knowledge-based systems involve a process known as knowledge engineering, which is typically carried out by a specialized systems analyst called a knowledge engineer. Knowledge engineering represents a system development methodology that shares similarities with traditional software development processes but focuses specifically on capturing and representing expert knowledge.

Knowledge engineering includes several key activities necessary for building a knowledge-based system:

1) Problem Identification and Characterization. This step involves defining the specific problem that the system is intended to address. It includes determining the type of problem such as diagnosis, prediction, simulation, or planning and identifying the relevant problem domain, for example disease management, nurse scheduling, or equipment troubleshooting.

2) Requirement Analysis. At this stage, the potential users of the system are identified, and the type of information the system must provide is determined. The goal is to define how the system will deliver meaningful and useful information to support decision-making.

3) Knowledge Acquisition. Knowledge acquisition involves identifying, gathering, and modeling the information required for the system. This information can be obtained from several sources, including:

- Written documentation such as technical reports, company manuals, books, and notes.
- Data records available in written or electronic formats.

- Human experts whose knowledge is captured through interviews, observation, and other elicitation techniques.

During this process, knowledge engineers aim to understand not only the expert's domain knowledge but also their reasoning and problem-solving strategies.

4) Program Development. In this phase, the acquired knowledge is implemented within the expert system or knowledge-based system using appropriate development tools or programming languages.

5) Installation and Testing. The final stage involves deploying the system and evaluating its performance. The output of the expert system or knowledge-based system is compared against predefined performance criteria to verify and validate that the system functions correctly and provides reliable results.

Expert Systems: Concept and Definition [3]

The term *expert system* describes a computer-based system that uses modern computing technology to store, process, and apply the knowledge and experience of one or more human experts in a specific domain. By accessing this stored knowledge, users are able to obtain guidance and recommendations similar to those provided by specialists in that particular field.

According to Edward Feigenbaum, an expert system can be defined as *an intelligent computer program that applies knowledge and inference procedures to solve problems that normally require substantial human expertise*. The knowledge incorporated into such systems, along with the inference mechanisms used to process it, represents a model of the expertise possessed by leading professionals within a particular domain.

The knowledge contained within an expert system generally consists of facts and heuristics. Facts represent widely accepted information that is publicly available and commonly shared among experts in a given field. In contrast, heuristics are informal rules or strategies based on experience and practical judgment that guide expert-level decision making. The effectiveness and performance of an expert system largely depend on the quantity and quality of the knowledge stored in its knowledge base.

The development of knowledge-based expert systems is carried out by specialists known as knowledge engineers, and the methodology used for building these systems is referred to as knowledge engineering. Knowledge engineers aim to reproduce the reasoning and problem-solving behavior of human experts within a particular domain. Their goal is to design computer systems capable of producing solutions that resemble those generated through human intelligence.

Expert systems and knowledge-based systems are typically designed to address specific types of problems. Among the most suitable tasks for such systems are:

1. Interpretation of data in order to assess and understand particular situations.
2. Construction of solutions when operating under a defined set of constraints.

One of the earliest examples of an expert system is the DENDRAL system developed at Stanford University. This system was designed to analyze spectroscopic data and determine the molecular structure of unknown chemical compounds. Another important early system is MACSYMA, developed at Massachusetts Institute of Technology, which was used for symbolic manipulation of algebraic expressions.

Structure of Expert Systems

Expert systems began to emerge during the 1970s as research in Artificial Intelligence advanced. During this period, researchers adopted concepts from the Human Information Processing System (HIPS) model of human cognition to design rule-based programming approaches known as production systems. A production system is based on the concept that knowledge can be represented as a set of rules, commonly expressed as condition–action pairs in the form: *IF a specific condition occurs, THEN perform a particular action.*

A production system typically consists of two primary elements:

1. A set of production rules, usually expressed as IF–THEN statements.
2. A working memory, which stores the current facts or information relevant to the problem being solved.

In simple terms, production rules act as instructions that allow the system to recognize specific conditions and execute appropriate actions. These rules operate on the information stored in the working memory.

Expert systems are constructed using such production rules derived from the Human Information Processing System model. The overall architecture of an expert system includes two main components: the knowledge base and the inference engine. The knowledge base also incorporates the working memory that stores problem-specific information during system operation.

Human experts are capable of solving complex problems because they rely on extensive domain-specific knowledge combined with heuristic reasoning. An expert can be described as an individual who is widely recognized for their ability to solve particular types of problems more effectively and efficiently than most other individuals.

Experts perform at a high level largely because they possess a significant amount of organized, task-specific knowledge stored in long-term memory. Research suggests that highly experienced specialists, such as distinguished chemists, may possess tens of thousands of pieces of heuristic knowledge related to their domain. This knowledge is structured in such a way that it enables experts to respond quickly and effectively to problem situations using both heuristics and domain theories.

The role of the knowledge engineer is to construct the knowledge base of an expert system by capturing the expertise of human specialists. This process typically involves interviewing experts, analyzing their explanations, and identifying the key concepts, objects, and relationships that characterize knowledge within the domain. The knowledge engineer organizes these elements and their interconnections so that they can be represented within the expert system.

The main components of an expert system include [4]:

1. Knowledge Base

2. Inference Engine

In rule-based expert systems, the knowledge base is composed of two main elements:

- Working memory, which stores facts about the current problem situation.
- Rule base, which contains a collection of IF–THEN rules representing expert knowledge.

The inference engine is the reasoning mechanism that applies rules to the facts stored in working memory. It evaluates conditions, selects applicable rules, and derives conclusions or recommended actions. Logical reasoning methods such as the Modus Ponens principle are often used to infer conclusions (consequents) from known conditions (antecedents).

Methods of Knowledge Representation

One of the most critical stages in developing an expert system is the representation of knowledge. Research in knowledge representation within Artificial Intelligence has focused primarily on defining appropriate syntax and semantics for expressing knowledge in a form that computers can process.

In rule-based systems, factual information can be represented in several ways. A commonly used approach is predicate calculus, where rules establish relationships between conditions and outcomes. In such systems, a rule connects one or more antecedents (conditions) with corresponding consequents (results) [5]. For example:

- IF <antecedent 1> THEN <consequent 1>
- IF <antecedent 2> AND <antecedent 3> THEN <consequent 2>

The antecedent of a rule represents a statement describing the observed or inferred state of the environment. The consequent, on the other hand, may represent either a conclusion derived from the conditions or an action that should be executed.

Over time, Artificial Intelligence researchers have proposed various techniques for representing knowledge in computer systems, with an increasing focus on semantic meaning. Some of the widely used knowledge representation methods include:

- Semantic networks
- Object–Attribute–Value (O-A-V) structures
- Rules
- Frames
- Logical expressions

Semantic Networks

The concept of semantic networks was first introduced by Ross Quillian and later became an important approach in knowledge representation. A semantic network consists of interconnected nodes and links. Nodes represent objects or concepts, while links define the relationships between them.

Objects represented in the network may refer to physical entities or abstract concepts. Descriptive information about these objects is also stored within the network structure. The connections between nodes indicate relationships such as classification, ownership, or association. Two major advantages of semantic networks are their flexibility and their ability to support inheritance, allowing properties of higher-level concepts to be passed to related lower-level concepts.

Object–Attribute–Value (O–A–V)

Another technique for representing knowledge is the Object–Attribute–Value (O–A–V) model. In this approach:

- Object (O) represents a physical or conceptual entity.
- Attribute (A) describes a characteristic or property of that object.
- Value (V) specifies the particular value associated with the attribute in a given context.

The O–A–V structure can be considered a specialized form of the semantic network approach. In expert systems, factual knowledge and rules stored in the knowledge base represent static knowledge. When users interact with the system and provide values for different attributes related to a specific problem, dynamic knowledge is generated. This information is temporarily stored in the working memory and used by the reasoning mechanism. The process of assigning specific values to attributes in the knowledge base is often referred to as instantiation.

Rules

Rule-based representation is one of the most widely used and easiest methods to understand. The fundamental idea is that a particular problem can be solved by applying an appropriate set of rules. Each rule describes a condition and the corresponding action or conclusion that follows from that condition.

Typically, rules are written in the form of production statements:

IF condition THEN action

Logical operators such as IF, THEN, AND, and OR are commonly used to define relationships between conditions.

Example rules include:

- IF there is a holiday at the university THEN employees do not need to apply for leave when traveling outside the station.
- IF a student studies Library Science AND is enrolled at BHU THEN the student is eligible for the Das scholarship.

Another example from a medical diagnosis system:

- Rule 1: IF the organism grows in chains, pairs, and clumps THEN the organism is *streptococcus*.
- Rule 2: IF the organism is *streptococcus* THEN the infection is bacterial.
- Rule 3: IF the infection is bacterial AND the patient has no allergies THEN treatment with penicillin is recommended.

Logical Expressions

Logical reasoning provides another method for representing knowledge. Two commonly used logical systems in knowledge representation are propositional logic and predicate calculus.

In propositional logic, knowledge is expressed through statements that can be evaluated as either true or false. These statements are connected using logical operators such as AND, OR, NOT, IMPLIES, and EQUIVALENT. The purpose of propositional logic is to determine the truth of combined statements based on these logical relationships.

A knowledge base in an expert system may contain different types of knowledge, including behavior

descriptions, vocabulary definitions, object relationships, decision rules, typical situations, hypotheses, uncertain facts, processes, constraints, heuristics, and alternative or disjunctive facts.

Inference Engine

The inference engine is the component of an expert system responsible for deriving conclusions from the knowledge stored in the knowledge base. The knowledge base contains rules and facts related to a specific domain, while the inference engine applies these rules to available facts in order to generate conclusions or recommend actions.

The inference process is mainly based on logical reasoning methods such as Modus Ponens and Resolution (logic). For example, if a fact A is true and there is a rule *IF A THEN B*, the system can logically conclude that B is true. Expert systems must also handle uncertainty, which may arise from incomplete data, unreliable information, or conflicting rules.

The control mechanism of the inference engine determines how reasoning proceeds. Two main strategies are commonly used:

- Forward chaining – a data-driven approach that starts from known facts and applies rules to derive new conclusions.
- Backward chaining – a goal-driven approach that starts with a hypothesis and works backward to verify it using existing rules.

Additionally, reasoning processes may use search strategies such as depth-first or breadth-first search and may follow either monotonic reasoning, where facts remain true once established, or non-monotonic reasoning, where previously accepted facts can be revised.

2. Statement of the problem

The considered problem consists of eight input variables and one output variable. All these variables are described using linguistic terms. The linguistic representation allows the modeling of uncertain and imprecise information. Such an approach is commonly used in fuzzy rule-based decision-making systems (Table 1).

Table 1.

Fuzzy IF…Then rules

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
1	VS	VS	QS	U	QS	QS	VS	S	S
2	VS	S	VS	VS	VS	S	QS	QS	S
3	S	S	S	S	QS	QS	QS	QS	S
4	LS	S	LS	QS	VS	S	S	S	S

Table 2.

The encoded linguistic terms for values of job satisfaction facets

Scale	Level of Satisfaction	Linguistic value
1.	Unsatisfied (U)	$\left\{\frac{1}{1},\frac{0.5}{1.5},\frac{0}{2}\right\}$
2.	Less Satisfied (LS)	$\left\{\frac{0}{1},\frac{0.5}{1.5},\frac{1}{2},\frac{1}{2.5},\frac{0.5}{2.75},\frac{0}{3}\right\}$
3.	Quite Satisfied (QS)	$\left\{\frac{0}{2.5},\frac{0.5}{2.75},\frac{1}{3},\frac{1}{3.5},\frac{0.5}{3.75},\frac{0}{4}\right\}$
4.	Satisfied (S)	$\left\{\frac{0}{3.5},\frac{0.5}{3.75},\frac{1}{4},\frac{1}{4.5},\frac{0.5}{4.75},\frac{0}{5}\right\}$
5.	Very Satisfied (VS)	$\left\{\frac{0}{4.5},\frac{0.5}{4.75},\frac{1}{5}\right\}$

3. Solution of the problem

Then current input information is described by the following fuzzy numbers:

$$X'_1=\left\{\frac{1}{1},\frac{0.5}{1.5},\frac{0}{2}\right\}, X'_2=\left\{\frac{0}{1},\frac{0.5}{1.5},\frac{1}{2},\frac{1}{2.5},\frac{0.5}{2.75},\frac{0}{3}\right\}, X'_3=\left\{\frac{1}{1},\frac{0.5}{1.5},\frac{0}{2}\right\},$$

$$X'_4=\left\{\frac{0}{1},\frac{0.5}{1.5},\frac{1}{2},\frac{1}{2.5},\frac{0.5}{2.75},\frac{0}{3}\right\}, X'_5=\left\{\frac{0}{1},\frac{0.5}{1.5},\frac{1}{2},\frac{1}{2.5},\frac{0.5}{2.75},\frac{0}{3}\right\}, X'_6=\left\{\frac{0}{4.5},\frac{0.5}{4.75},\frac{1}{5}\right\}, X'_7$$

$$=\left\{\frac{0}{1},\frac{0.5}{1.5},\frac{1}{2},\frac{1}{2.5},\frac{0.5}{2.75},\frac{0}{3}\right\}, X'_8=\left\{\frac{1}{1},\frac{0.5}{1.5},\frac{0}{2}\right\}$$

1. $D(X'_1, X_{11}) = 1{,}32$;
   $D(X'_2, X_{12}) = 0.84$;
   $D(X'_3, X_{13}) = 0.79$;
   $D\big((X'_4, X_{14})\big) = 0.29$;
   $\boldsymbol{D(X', X_1) = 6.49}$;
2. $D(X'_1, X_{21}) = 1{,}37$;
   $D(X'_2, X_{22}) = 0.81$;
   $D(X'_3, X_{23}) = 1.37$;
   $D(X'_4, X_{24}) = 1.13$;
   $D(X'_5, X_{15}) = 0{,}39$;
   $D(X'_6, X_{16}) = 0.58$;
   $D(X'_7, X_{17}) = 1{,}13$;
   $D(X'_8, X_{18}) = 1{,}15$;
   $D(X'_5, X_{25}) = 1.13$;
   $D(X'_6, X_{26}) = 0.25$;
   $D(X'_7, X_{27}) = 0.43$;
   $D(X'_8, X_{28}) = 0.74$;

$$\boldsymbol{D(X', X_2) = 6.93;}$$

3. $D(X'_3, X_{31}) = 1{,}13;$ $D(X'_3, X_{35}) = 0.43;$
$D(X'_3, X_{32}) = 0.79;$ $D(X'_3, X_{36}) = 0.62;$
$D(X'_3, X_{33}) = 1.13;$ $D(X'_3, X_{37}) = 0.43;$
$D(X'_3, X_{34}) = 0.79;$ $D(X'_3, X_{38}) = 0.74;$

$$\boldsymbol{D(X', X_3) = 6.06;}$$

4. $D(X'_4, X_{41}) = 0.32;$ $D(X'_4, X_{45}) = 1.13;$
$D(X'_4, X_{42}) = 0.81;$ $D(X'_4, X_{46}) = 0.25;$
$D(X'_4, X_{43}) = 0.34;$ $D(X'_4, X_{47}) = 0.81;$
$D(X'_4, X_{44}) = 0.43;$ $D(X'_4, X_{48}) = 1.14;$

$$\boldsymbol{D(X', X_4) = 5.23;}$$

Finally, given the obtained values of the distance we computed overall job satisfaction as

$$Y = 0.25Y_1 + 0.26Y_2 + 0.23Y_3 + 0.26Y_4$$

The obtained result is

$$Y = \left\{\frac{0}{3.5}, \frac{0.5}{3.79}, \frac{1}{4}, \frac{1}{4.51}, \frac{0.5}{4.76}, \frac{0}{5}\right\}.$$

4. Conclusion

Consequently, in conclusion, IF–THEN rule-based decision making is an effective approach to deal with complex situations where the information might be uncertain and imprecise. IF–THEN rule-based decision making is a knowledge representation approach that uses simple and understandable rules to map inputs to outputs. The use of linguistic terms is natural for imprecise and vague information processing. By evaluating a given set of rules, the decision-making system is able to produce reliable and understandable results. As a result, IF–THEN rule-based decision making is commonly used in fuzzy systems and intelligent control systems.

References

1. Eyupoglu, S. Z., Saner, T., Jabbarova, K.I.: Job satisfaction: an evaluation using a fuzzy approach. Procedia Computer Science 120, 691-698 (2017).

2. Jabbarova, K.İ., Rzayeva, U., Jabbarova, A.: Development of the method of general interpolation for Z-number-valued if-then rules. East.-Eur. J. Enterp. Technol. 4(4 (124))19-26 (2023).

3. Eyupoglu, S. Z., Jabbarova, K.I.,Aliyeva, K.R.: The Identification of Job Satisfaction under Z-Information. Intell. Autom. Soft Comput. 24, 1-5 (2017).

4. Aliev, R.A., Pedrycz, W., Guirimov, B.G., Huseynov, O.H.: Clustering method for production of Z-number based if-then rules. Inform. Sci. 520, 155–176 (2020).

5. Wu, H., Xu, Z.S.: Fuzzy logic in decision support: Methods, applications and future trends. Int. J. Comput. Commun. Control. 16(1), 4044 (2021).

МАЛОГАБАРИТНЫЙ ПРИБОР: «ЭЛЕКТРОННАЯ НАГРУЗКА ДЛЯ ИСТОЧНИКОВ ПИТАНИЯ»

Джаманбалин К.К.,
д-р физико-математических наук, профессор
Костанайского социально-технического университета имени академика З. Алдамжар
Джаманбалин Б.К.
доктор PhD
Костанайского социально-технического университета имени академика З. Алдамжар

SMALL-SIZED DEVICE: "ELECTRONIC LOAD FOR POWER SUPPLIES"

Jamanbalin K.,
Dr. Physical and Mathematical Sciences, Professor
Kostanay Socio-Technical University named after academician Z. Aldamjar
Jamanbalin B.
Dr, PhD, Kostanay Socio-Technical University named after academician Z. Aldamjar
DOI: 10.5281/zenodo.19327419

АННОТАЦИЯ

В статье рассматриваются автоматизированные средства измерительной техники, обеспечивающие согласованность их технических характеристик и эксплуатационных параметров в соответствии с требованиями, необходимые для эксплуатации электродвигателей. Существуют различные автоматизированные стенды для испытания электродвигателей различных типов. В нашем случае для определения входных и выходных характеристик электродвигателей, предлагается малогабаритный прибор, в котором в качестве нагрузки может быть использованы различные приборы, в том числе и электродвигатели. Малогабаритный прибор предназначен для оперативное оценки состояния электрических машин. Предлагаемый малогабаритный прибор позволяет проводить испытания электродвигателей дома, в ремонтном цеху или на предприятии. Это позволяет техническому персоналу оценить потребность в ремонте или замене определенных электродвигателей и генераторов путем проведения как низковольтных, так и высоковольтных испытаний.

ABSTRACT

The article discusses automated measuring equipment that ensures the consistency of their technical characteristics and operational parameters in accordance with the requirements necessary for the operation of electric motors. There are various automated testing stands for different types of electric motors. In our case, a small-sized device is proposed for determining the input and output characteristics of electric motors, which can use various devices, including electric motors, as a load. The small-sized device is designed for an operational assessment of the condition of electric machines. The proposed small-sized device allows testing of electric motors at home, in a repair shop or at the enterprise. This allows technical personnel to assess the need for repair or replacement of certain electric motors and generators by conducting both low-voltage and high-voltage tests.

Ключевые слова: активное сопротивление, электронная нагрузка, источник электрического питания, малогабаритный прибор, солнечные батареи, аккумуляторы: гелиевые, щелочные, мультиметр.

Keywords: ctive resistance, electronic load, electric power supply, small-sized device, solar panels, batteries: helium, alkaline, multimeter.

Введение

Для имитации работы электрических нагрузок широкое применение находят устройства, представляющие собой схему, поглощающую электрическую энергию источника и функционально являющиеся регулируемым эквивалентом активного сопротивления с возможностью поглощения больших мощностей. Такая электронная нагрузка (ЭН) позволяет испытывать современные полупроводниковые преобразователи электрической энергии для реализации всевозможных схемотехнических решений. Большинство электронных нагрузок способны выполнять как роль нагрузочного элемента, так и средства измерения с возможностью отображения на дисплее различных параметров нагружаемого источника (ток, напряжение, мощность и т.д.) [1.2].

Цель настоящего исследование было создание малогабаритного прибора «Электронная нагрузка для источников питания».

Изобретение относится к направлению приборостроения, в области разработки различных источников электрического питания.

Описание предлагаемого изобретения.

В имеющихся аналогах приборы электронной нагрузки имеют несколько блоков различного назначения и вмонтированы в один общий блок. При этом они имеют ряд недостатков, например, они не

малогабаритный, требующих особых условий эксплуатации.

В имеющихся аналогах приборы электронной нагрузки имеют несколько блоков различного назначения и вмонтированы в один общий блок. При этом они имеют ряд недостатков, например, они не малогабаритный, требующих особых условий эксплуатации.

Малогабаритный прибор: «Электронная нагрузка для источников питания» предназначенный для тестирования режимов работы различных источников питания, и отличающийся тем, что

- позволяет существенно ускорить процесс тестирования любых источников электропитания, а также обеспечить безопасность процесса и эффективность;
- может выполнять задачу нагрузочного элемента, с отображением различных параметров нагружаемого источника;
- может быть использована не только как нагрузочные элементы, но и как средства измерения основных параметров источников питания.
- тестирование различных источников питания:
  - Аккумуляторов(гелиевые, щелочные, легионные);
  - Лабораторных блоков питания;
  - Преобразователей напряжения;
  - Солнечных батарей;
  - Зарядных устройств (смартфонов, планшетов, ноутбуков и других электронных приборов).

И состоящий из:

- мультиметр- измеряющий ток, напряжение потребляемой нагрузкой;
- вентилятор;
- радиатор, на котором установлены четыре полевых транзистора;
- на монтажной плате расположена четырех канальная микросхема (операционный усилитель) LM 324;
- на основе микросхемы TL 431 реализован параметрический стабилизатор напряжения;
- резистор R 23 (4,7 кОм) регулирует ток нагрузки от 0 до 10 ампер.

Включающий работу в различных режимах потребления:

- Режим постоянного тока потребления;
- Режим постоянной мощности;
- Режим постоянного сопротивления;

Имеющая следующие характеристики:

- Максимальная мощность нагрузки P = 150 Вт.
- Регулировка тока в пределах от 0 до 20 ампер.
- Максимальное входное напряжение – 7-вольт.
- Размеры:160мм х 130мм х110мм)

Внешний вид малогабаритного прибора «Электронная нагрузка для источников питания» подключённый к тестируемой нагрузкой предстален на рис.1. «Электронная нагрузка для источников питания» **собрана на операционном усилителе LM324.**

Рис. 1 Малогабаритный прибор «Электронная нагрузка для источников питания» подключённый к тестируемой нагрузкой

Установка позволяет работу в независимых режимах.

- выполнять задачу нагрузочного элемента, с отображением различных параметров нагружаемого источника
- может быть использована не только как нагрузочные элементы, но и как средства измерения основных параметров источников питания.
- позволяет подтвердить заявленную емкость аккумулятора.

В электронной нагрузке вся мощность выделяется на силовых транзисторах. При этом электронную нагрузку можно делать на любую мощность

Результаты

Поскольку электронные нагрузки предназначены для имитации различных режимов работы источников питания, они являются эффективным средством повышения результативности испытаний. Приведем несколько примеров. Проверка AC/DC и DC/DC преобразователей. С помощью электронной нагрузки можно наиболее быстро и эффективно проверить работу AC/DC и DC/DC-преобразователей. ЭН может имитировать включение и выключение устройства, проверять уровни пульсаций напряжения и тока, оценивать уровень шумов и помех и т.д.

Проверка аккумуляторов. Проверка аккумулятора с помощью ЭН в режиме PPM обеспечивает

постоянное потребление энергии во всем диапазоне времени тестирования и предоставляет истинные, либо максимально близкие к истинным, результаты.

Проверка солнечных батарей. С помощью ЭН, запрограммированной на имитацию различных состояний, можно проверять портативные устройства при различных состояниях питания, таких как: «спящий» режим, энергосбережение и режим полной мощности.

Литература

1. Корнев А.А. Электронная нагрузка для испытаний источников питания.// Орловский государственный университет, Орел, 2018 – 71 с.

2. Алешкин Д.В., Гуляев И.В. Использование электронной нагрузки для исследования современных преобразователей электрической энергии.// Интеллектуальная электротехника, 2020, № 4, с.82-92.

3. Серков Д. Электронные нагрузки АКИП – эффективный инструмент тестирования LED-драйверов // Электроника: наука, технология, бизнес. 2012. № 7 (121). С. 98-101.

СТРАТЕГИЯ ТЕСТИРОВАНИЯ МИГРАЦИИ КОНТЕНТА И ДАННЫХ В КРУПНЫХ DRUPAL-ПРОЕКТАХ

Кулецкая Е.А.
старший инженер по обеспечению качества, специалист по обеспечению качества в области корпоративных веб-систем и систем на базе-Drupal,
США, Вэстовер

TESTING STRATEGY FOR CONTENT AND DATA MIGRATION IN LARGE DRUPAL PROJECTS

Kuletskaia E.
Senior Quality Assurance Engineer,
Quality Engineering Specialist in Enterprise Web and Drupal-Based Systems,
USA, Westover
DOI: 10.5281/zenodo.19327431

АННОТАЦИЯ

Статья посвящена стратегии тестирования миграции контента и данных в крупных Drupal-проектах при переходе на современные версии. Рассмотрены методологические основы миграции на базе разграничения контентных и конфигурационных сущностей и применения Migrate API. Показано, что качество переноса определяется сохранением целостности данных, связей между сущностями и трассируемости соответствий. Обоснован подход к тестированию как воспроизводимому циклу с использованием инструментов экосистемы Drupal, включая предварительную проверку результатов и элементы автоматизации.

ABSTRACT

The article is devoted to the strategy for testing content and data migration in large Drupal projects when migrating to modern versions. The methodological foundations of migration based on the differentiation of content and configuration entities and the use of the Migrate API are considered. It is shown that the quality of migration is determined by the preservation of data integrity, relationships between entities, and traceability of correspondences. The approach to testing as a reproducible cycle using the tools of the Drupal ecosystem, including preliminary verification of results and elements of automation, is substantiated.

Ключевые слова: Drupal, миграция данных, интерфейс миграции, тестирование миграции, целостность данных, связи сущностей, карты миграции, инструменты командной строки, средства управления миграциями, автоматизированные тесты миграции.

Keywords: Drupal, data migration, migration interface, migration testing, data integrity, entity relationships, migration maps, command-line tools, migration management tools, automated migration tests.

Актуальность исследования

Актуальность исследования обусловлена тем, что во многих организациях продолжают использоваться устаревшие версии Drupal, а переход на современные версии требует переноса больших массивов данных с сохранением целостности, связей между сущностями и прикладной логики. Обзор распространённости версий Drupal в открытых источниках показывает, что заметная часть сайтов попрежнему работает на старых ветках, поэтому миграции остаются массовой и регулярно возникающей задачей сопровождения и развития цифровых платформ.

Дополнительную значимость этой проблематике придаёт завершение официальной поддержки Drupal версии семь: на Drupal.org указано, что после даты окончания поддержки ядро Drupal версии семь больше не получает обновления безопасности и исправления, а дальнейшая эксплуатация повышает риски уязвимостей и осложняет выполнение требований информационной безопасности и комплаенса. В результате миграция превращается не только в этап модернизации, но и в меру управления рисками, где критически важно контролировать качество переноса данных.

При этом сама экосистема Drupal рассматривает миграцию как инженерный процесс, требующий проверяемости: в официальной документации описаны механизмы миграции и подходы к тестированию миграций, что подчёркивает необходимость системной стратегии тестирования для подтверждения корректности переноса и предупреждения регрессий в функциональности. Для крупных проектов, где миграция затрагивает множество типов контента, пользовательские роли, мультиязычность, интеграции и бизнес-процессы, отсутствие формализованного тестирования повышает вероятность незаметных ошибок, которые проявляются уже в продуктивной эксплуатации.

Цель исследования

Целью данного исследования является обоснование и формализация стратегии тестирования миграции контента и данных в крупных Drupal-проектах, обеспечивающей проверяемость, воспроизводимость и контролируемое качество переноса с сохранением целостности данных, связей между сущностями и работоспособности прикладной логики.

Материалы и методы исследования

Материалами исследования выступили открытые официальные источники экосистемы Drupal: документация по Entity API, Configuration API и Migrate API, а также описания практик выполнения и отладки миграций и инструментария управления миграциями (Drush/Migrate Tools), сведения о средствах предварительного просмотра результатов миграции и о встроенных механизмах автоматизированных migration tests.

Методическая основа включает анализ нормативно-технических описаний и функциональных возможностей указанных компонентов, логико-структурное моделирование процесса миграции «источник – преобразование – назначение», а также сравнительный анализ подходов к проверке результата на уровнях данных, связей и воспроизводимости миграционных прогонов.

Результаты исследования

Миграция данных в Drupal методологически опирается на различение видов информации, которые система хранит и обрабатывает по-разному: пользовательские данные представлены сущностями контента, а настройки и структурные элементы сайта – конфигурацией. В документации Drupal подчёркивается, что контентные сущности предназначены для хранения пользовательских данных, состоят из базовых и настраиваемых полей, могут поддерживать ревизии и переводы и физически размещаются в таблицах базы данных. Одновременно конфигурационные сущности используются для хранения и обмена системными настройками; они экспортируемы и могут быть помещены под контроль версий, что делает конфигурацию самостоятельным объектом переноса и проверки при развертывании между окружениями. Этот дуализм определяет границы миграции данных: перенос «контента» не сводится к копированию записей из базы, а перенос «настроек» не должен имитироваться через миграцию, поскольку для него предусмотрены собственные механизмы конфигурационного управления [1].

Ключевое методологическое последствие для крупных проектов состоит в том, что модель данных в Drupal описывается через типы сущностей, их «пакеты» и поля, а сами поля определяются через систему типизированных данных и явные определения полей. В документации по Entity API отдельно указывается, что поля контентных сущностей должны быть определены через определения полей, основанные на Typed Data API, то есть структура данных формализуется на уровне типов и ограничений, а не только на уровне «значений в колонках». Это важно для миграции, потому что преобразования должны обеспечивать соответствие типам и ограничениям целевой модели (например, форматам значений, обязательности полей, допустимым диапазонам и структурам сложных полей), а несоответствие проявляется как ошибки валидации или скрытые дефекты в данных.

В руководствах Drupal также фиксируется, что экосистема разделяет «простую конфигурацию» и «конфигурационные сущности», а Configuration API рассматривается как централизованный способ хранения конфигурационных данных модулей. Это позволяет корректно задавать методику миграции: контентные сущности мигрируют как данные, конфигурационные сущности – как экспортируемые объекты конфигурации, а простая конфигурация переносится через конфигурационные хранилища и процедуры импорта/экспорта, а не через Migrate API. Такой подход снижает риск смешения «данных эксплуатации» и «данных настройки», что особенно критично для крупных Drupal-решений с множеством окружений и регулярными поставками.

В таблицу 1 сведены три категории информации, которые Drupal описывает в официальной документации и которые на практике требуют разных методов переноса и разных критериев корректности.

Таблица 1

Классификация типов данных в Drupal и соответствующие механизмы их переноса и контроля

Категория в Drupal	Что хранит	Метод переноса/контроля в типовой практике
Контентные сущности	Пользовательские данные, создаваемые в ходе эксплуатации; поля; возможны переводы и ревизии; хранение в таблицах БД	Миграция через Migrate API или другие процедуры переноса данных; обязательна проверка целостности и соответствия типам
Конфигурационные сущности	Настройки и структурные элементы; экспортируемость; возможность контроля версий	Экспорт/импорт конфигурации и поставка между окружениями; проверка соответствия конфигурации окружениям
Конфигурация как класс данных (Configuration API)	Централизованное хранение конфигурационных данных модулей; разграничение типов информации в Drupal	Управление конфигурационными хранилищами и процессами импорта/экспорта

Источник: [2].

Технической основой миграции данных в современном Drupal является Migrate API, который в руководствах описывается как система сервисов для переноса данных из исходной системы в актуальную версию Drupal. Методологически данный механизм представляет собой последовательный

процесс: данные извлекаются источником, проходят этап преобразования в слое process и затем записываются в назначение. Источники реализуются в виде source-плагинов и могут работать, в частности, с CSV-файлами, SQL-таблицами и JSON. Преобразования выполняются через process-плагины, формируя воспроизводимую цепочку операций. Назначение определяется destination-плагином, который задаёт тип создаваемых сущностей, обычно в формате entity:entity_type, что связывает миграцию с моделью сущностей целевой системы.

Важным элементом корректной миграции является обеспечение трассируемости соответствий между исходными и созданными объектами. Для этого используются карты миграции, фиксирующие связь между записью источника и сущностью назначения. Эти данные применяются при восстановлении ссылок и зависимостей, в том числе через механизм migration_lookup. Таким образом, миграция рассматривается как управляемый процесс с контролируемой историей соответствий, что имеет значение при переносе связанных сущностей, вложенных структур и мультиязычных данных.

Документация по Migrate API также указывает на поддержку межверсийного апгрейда, включая перенос сайтов с более ранних версий Drupal на современные. Это означает, что миграция является стандартным предусмотренным сценарием развития системы. В крупных проектах часть данных переносится средствами базовых модулей апгрейда, тогда как кастомные структуры и интеграционные данные требуют отдельных миграций, при сохранении общей модели «источник – преобразование – назначение» и механизма карт соответствий.

На рисунке ниже представлена схема работы карт миграции в рамках Migrate API Drupal, которая демонстрирует, что миграция в Drupal включает не только перенос значений полей, но и формирование устойчивого механизма трассируемости, обеспечивающего восстановление связей между объектами при последующих операциях и зависимых миграциях.

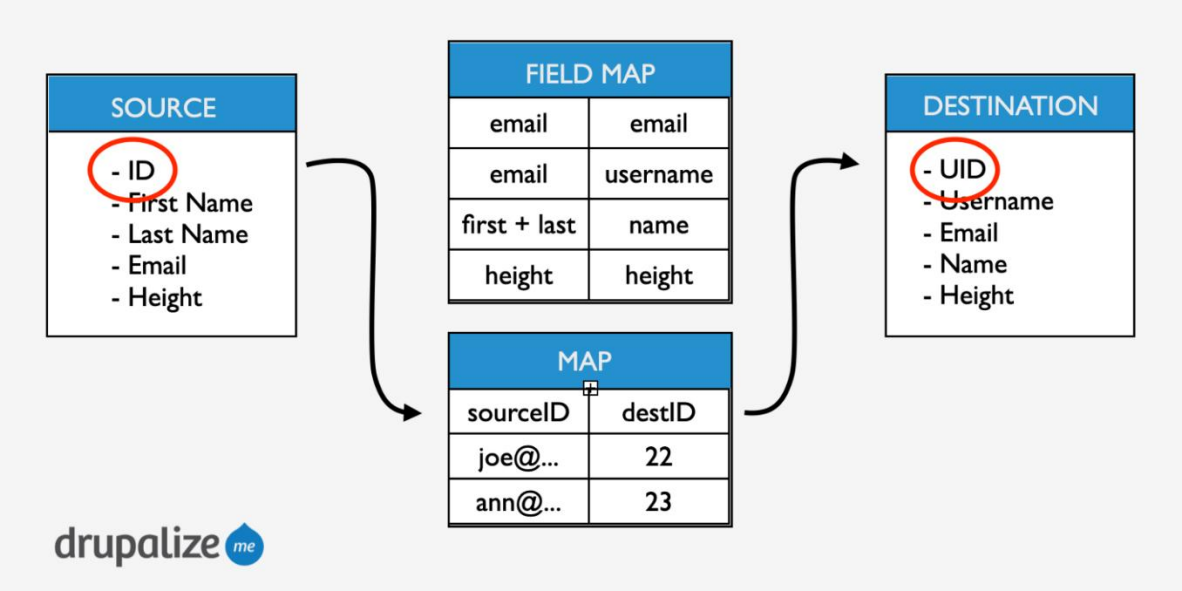


Рис. Принцип формирования карт миграции в Drupal [3]

Стратегия тестирования миграции данных в Drupal опирается на принцип воспроизводимости: миграция должна выполняться в повторяемых условиях, с контролируемыми параметрами и с возможностью отката результатов при выявлении дефектов. В описании по выполнению миграций подчёркивается использование Drush-команд (через Migrate Tools) для выполнения импорта и отката, а также возможность ограниченного запуска, когда переносится только часть строк источника для первичной проверки результатов и корректировки настроек. Такая практика переводит проверку миграции из разового действия в управляемый цикл: пробный запуск, анализ результата, корректировка сопоставлений и повторный запуск после отката. Для крупных проектов это критично, поскольку объём данных и количество типов сущностей делают ручную проверку «после полного переноса» рискованной и затратной.

В таблице 2 описаны команды Drush для воспроизводимого тестирования миграций.

Таблица 2

Команды Drush для воспроизводимого тестирования миграций

Команда	Назначение в контуре тестирования	Что проверяется/фиксируется
migrate:status	Получение списка миграций и их статусов	Готовность миграций к запуску, отсутствие «зависших» операций
migrate:import	Выполнение импорта миграции	Корректность переноса на выбранном наборе данных; возможность итеративной проверки (в том числе с ограничением числа строк)
migrate:rollback	Откат результатов миграции	Повторяемость тестовых прогонов, корректность очистки созданных объектов
migrate:messages	Просмотр сообщений, связанных с выполнением	Ошибки преобразований, предупреждения, проблемные записи источника
migrate:stop	Корректная остановка выполняющейся операции	Управляемость процесса при длительном выполнении
migrate:reset-status	Сброс статуса миграции в «idle» при некорректном завершении	Восстановление возможности повторного запуска после сбоя
migrate:tree	Просмотр зависимостей миграций	Правильный порядок прогонов при наличии зависимых переносов
migrate:fields-source	Просмотр доступных полей источника для маппинга	Полнота описания входных данных и корректность выбора свойств для сопоставления

Источник: [4].

Для снижения риска «перенесли и только потом увидели ошибки» в стратегию тестирования целесообразно включать предварительную проверку результатов трансформации без выполнения фактического импорта. В открытом доступе существует модуль Migrate Preview, который прямо заявляет возможность посмотреть, как будут выглядеть данные, без запуска миграции, расширяя интерфейс Migrate Tools вкладкой предварительного просмотра. Такой подход полезен как ранний контроль качества сопоставлений и преобразований: до создания сущностей в целевой системе можно выявить некорректные значения, ошибки преобразований и несоответствия структуры данных.

Надёжная стратегия тестирования включает автоматизацию, встроенную в Drupal. В руководствах Drupal.org описаны migration tests: для них используются тестовые базы данных (fixtures) Drupal 6 и Drupal 7, а также приводится пример функционального теста сценария обновления через интерфейс /upgrade. На уровне ядра предусмотрена база для kernel-тестов миграций – абстрактный класс Drupal\Tests\migrate\Kernel\MigrateTestBase, описанный на api.drupal.org. Это позволяет выстраивать тестирование как сочетание функциональных проверок пользовательского процесса обновления и kernel-проверок корректности выполнения миграции в изолированной тестовой среде.

Практическая реализация стратегии тестирования миграции в крупном Drupal-проекте обычно начинается с того, что в тестовом контуре обеспечивается полноценная доступность исходных артефактов: базы данных старого сайта и файлового хранилища (как минимум публичных файлов, а при наличии – и приватных). В официальных рекомендациях по подготовке к апгрейду с Drupal 6/7 прямо указаны эти предпосылки: доступ к базе данных источника с того же хоста, где развёрнут новый сайт, и доступ к файлам исходного сайта (при использовании только публичных файлов допускается доступ по адресу сайта). На практике это переводится в проверяемую процедуру: до запуска миграционных прогонов фиксируется, что тестовое окружение видит источник данных и файлов, а также что права доступа и пути к файловым директориям соответствуют фактической структуре проекта.

Отдельного внимания в крупном проекте требует перенос файлов, потому что корректность ссылок на изображения и документы влияет на целостность контента так же, как и корректность записей в базе. В открытой практике миграции Drupal 7 → современные версии выделяют различия между публичными и приватными файлами и подчёркивают необходимость выстраивать перенос так, чтобы целевая система после миграции могла обслуживать оба типа хранилищ без «битых» ссылок и потерь доступа. В тестовой процедуре это обычно оформляется как отдельный набор проверок: наличие файлов на месте, воспроизводимость путей, корректность прав доступа и проверка выборки материалов, где используются файлы разных типов [5].

В длительных миграционных проектах применяют инкрементальные прогоны: повторно обрабатывают только те записи, которые появились или изменились после предыдущего запуска. В Migrate API для этого предусмотрены highwater marks – механизм отслеживания изменений, при котором выборка ограничивается данными «новее» последней зафиксированной отметки; для работы требуется, чтобы у source-плагина было задано свойство high_water_property. Это позволяет сначала подтвердить корректность полной миграции на тестовой копии, а затем поддерживать качество переносов проверками только «дельты» изменений.

Дополнительно в крупных миграциях контролируют технологическую сторону выполнения: служебные таблицы сопоставления миграций могут существенно разрастаться и становиться источником замедлений, что обсуждается в публичных задачах Drupal. Поэтому тестирование включает не только проверку правильности перенесённых данных, но и мониторинг времени прогонов и признаков деградации производительности по мере накопления записей.

Примеры практических технических рисков миграции на больших объёмах и их проверяемые признаки представлены в таблице 3.

Таблица 3

Примеры практических технических рисков миграции на больших объёмах и их проверяемые признаки

Риск в крупном проекте	Где проявляется	Как фиксируется в тестировании
Рост и «тяжёлые» операции по таблицам сопоставления	Таблицы migrate_map_*	Сравнение времени выполнения прогонов на одинаковых выборках, анализ признаков замедления; учёт обсуждаемых улучшений (индексация)
Некорректный перенос файлов (публичных/приватных)	Хранилище файлов и ссылки в контенте	Выборочная проверка материалов с файлами, проверка доступности по ролям и путям, отсутствие «битых» ссылок
Итерируемая миграция без повторной обработки всего массива	Источник данных при повторных прогонах	Проверка, что «дельта» переносится за счёт highwater marks при наличии high_water_property

Источник: разработка автора.

Выводы

Таким образом, стратегия тестирования миграции в Drupal должна рассматриваться как обязательная часть инженерного процесса перехода на современные версии и как инструмент управления рисками, усиливающимися после завершения поддержки устаревших веток. Качественная миграция достигается при разделении переноса контента и конфигурации, использовании стандартных механизмов Migrate API и контроле трассируемости соответствий через карты миграции, что критично для восстановления связей и зависимостей.

Практически эффективный подход строится как воспроизводимый цикл тестовых прогонов с возможностью отката, использованием диагностических сообщений, предварительным контролем результата до импорта и подключением автоматизированных migration tests. Для крупных проектов дополнительно необходимы регламентированные проверки доступности базы и файлового хранилища источника, контроль переноса публичных и приватных файлов, применение инкрементальных прогонов при длительных миграциях и мониторинг технологических рисков, связанных с ростом служебных таблиц и потенциальной деградацией производительности.

Литература

1. Configuration API [Электронный ресурс]. – Режим доступа: https://www.drupal.org/docs/drupal-apis/configuration-api.
2. Content Entity [Электронный ресурс]. – Режим доступа: https://www.drupal.org/docs/drupal-apis/entity-api/content-entity.
3. Debugging inconsistent return values from the Drupal migration_lookup plugin [Электронный ресурс]. – Режим доступа: https://drupalize.me/blog/debugging-inconsistent-return-values-drupal-migration-lookup-plugin.
4. Migrate Tools [Электронный ресурс]. – Режим доступа: https://www.drupal.org/project/migrate_tools.
5. Migrating your Data from D7 to D10: Public and private file migrations [Электронный ресурс]. – Режим доступа: https://www.tag1.com/blog/migrating-your-data-d7-d10-public-and-private-file-migrations/.

No 185 (2026)

Sciences of Europe
(Praha, Czech Republic)

ISSN 3162-2364
The journal is registered and published in Czech Republic.
Articles in all spheres of sciences are published in the journal.

Journal is published in Czech, English, Polish, Russian, Chinese, German and French, Ukrainian.
Articles are accepted each month.
Frequency: 24 issues per year.
Format - A4
All articles are reviewed
Free access to the electronic version of journal

Edition of journal does not carry responsibility for the materials published in a journal.
Sending the article to the editorial the author confirms it's uniqueness and takes full responsibility for possible consequences for breaking copyright laws.

Chief editor: Petr Bohacek
Managing editor: Michal Hudecek

- Jiří Pospíšil (Organic and Medicinal Chemistry) Zentiva
- Jaroslav Fähnrich (Organic Chemistry) Institute of Organic Chemistry and Biochemistry Academy of Sciences of the Czech Republic
- Rasa Boháček – Ph.D. člen Česká zemědělská univerzita v Praze
- Naumov Jaroslav S., MD, Ph.D., assistant professor of history of medicine and the social sciences and humanities. (Kiev, Ukraine)
- Viktor Pour – Ph.D. člen Univerzita Pardubice
- Petrenko Svyatoslav, PhD in geography, lecturer in social and economic geography. (Kharkov, Ukraine)
- Karel Schwaninger – Ph.D. člen Vysoká škola báňská – Technická univerzita Ostrava
- Václav Pittner -Ph.D. člen Technická univerzita v Liberci
- Dudnik Oleg Arturovich, Doctor of Physical and Mathematical Sciences, Professor, Department of Physical and Mathematical management methods. (Chernivtsi, Ukraine)
- Konovalov Artem Nikolaevich, Doctor of Psychology, Professor, Chair of General Psychology and Pedagogy. (Minsk, Belarus)

«Sciences of Europe» -
Editorial office: Křižíkova 384/101 Karlín, 186 00 Praha

E-mail: info@european-science.org
Web: www.european-science.org